FISHERIES INVESTIGATIONS IN LAKES AND STREAMS

ANNUAL PROGRESS REPORT

Statewide Freshwater Fishery Research

July 1, 2014 - June 30, 2015

James Bulak
Research Coordinator

Jason Bettinger
Kevin Kubach
Jean Leitner
Mark Scott
Barbara Taylor

Fisheries Biologists

Division of Wildlife and Freshwater Fisheries
Emily C. Cope, Deputy Director

TABLE OF CONTENTS

PAGE NO.

Study Title: STATEWIDE FISHERIES RESEARCH

Job Title: Hydroacoustic Evaluation of Santee-Cooper Lakes

Period Covered July 1, 2014 - June 30, 2015

Summary

Twelve hydroacoustic transects of Lakes Marion and Moultrie were completed in 2013; processing of this data is in progress. Threadfin shad *Dorosoma petenense*, blueback herring *Alosa aestivalis*, and American shad *Alosa sapidissima* comprised 84.6, 6.4, and 2.5% of the gill net catch of 3,824 fish. Length at date of American shad and blueback herring exhibited similar patterns that differed between 2013 and 2014.

Introduction

To understand fish population dynamics in the Santee-Cooper system, knowledge of the standing crop (kg/ha) and production is essential. Hydroacoustic technology allows these estimates to be made on the vast expanses of the Santee-Cooper lakes. Preliminary sampling in 2010 verified that the use of this technology on Santee-Cooper was practical. This report summarizes results obtained in the study year.

Materials and Methods.

Hydroacoustic and concurrent gill net sampling of Lakes Marion and Moultrie were conducted in summer and fall of 2014 with a Biosonics DTX system. Hydroacoustic transect sites, 6 to 8 km in length, were defined, three on Lake Marion and two on Lake Moultrie. Transect locations were defined as:

1. Eutaw Creek (EC), L. Marion, 33.44114, -80.36458 to 33.44168, -80.28794

2. Stump-Free Channel (SF), L. Marion, 33.48837, -80.27969 to 33.51086, -80.19805
3. Along dike and dam (DK), L. Marion, 33.51549, -80.18845 to 33.44925, -80.16536
4. West Dike (WD), L. Moultrie, 33.35431, -80.04438 to 33.29497, -80.08909
5. Bonneau to Pinopolis (PI), L. Moultrie, 33.30005, -79.99644 to 33.24618, -80.01282.

Hydroacoustic transects were initiated 45 minutes after sunset. Down and side-looking transects were conducted simultaneously. Digital files from the completed transects were sent to an outside contractor, Aquacoustics Inc., for processing and analysis.

Gill net sampling was conducted concurrently with hydroacoustic transects. A 1.83 m deep experimental gill net with 4.57 m sections of 6.35, 9.53, 12.70, 15.88, and 19.05 mm bar mesh was used. A floating and mid-water (i.e. float line was 3.05 m below surface) net were set at each transect site. Once the nets were retrieved, the catch was removed from the net, placed on ice, and brought to the laboratory for measurement of length and weight. For most clupeid fishes (American shad, blueback herring, Atlantic menhaden *Brevoortia tyrannus*, and gizzard shad *Dorosoma cepedianum*, a random sample of 30 from each mesh was measured (total length (TL), mm) and weighed (to 0.1 g); then, a random sample of the 10 was measured. For threadfin shad, a random sample of 10 from each mesh was measured TL (mm) and weighed (to 0.1 g); then, a random sample of the 30 was measured. If additional fish from a species remained after obtaining measurements, they were enumerated.

For American shad and blueback herring, we employed a linear regression of total length (dependent variable) vs. Excel date (where August 7, 2014 = 41,858) to estimate length at date for the period August 7 through November 3. An identical approach was used on data collected in 2013. Length at date in 2013 and 2014 was compared.

Results and Discussion

A total of 12 distinct transects were successfully sampled. Sampling plans called for collecting hydroacoustic data on 16 distinct transects from July through November. Weather, especially thunderstorms and wind, were troublesome, as windy conditions were not suitable for obtaining good results from the side-looking transducer.

Transect data was sent to the outside consultant for analysis and interpretation. These data were not fully processed as of the writing of this report.

July through November gill net surveys indicated that threadfin shad were the dominant species in the Santee-Cooper lakes. A total of 3,824 fish were collected. Threadfin shad comprised 84.6% of the catch. Blueback herring, Atlantic menhaden, American shad, and blue catfish *Ictalurus furcatus*, comprised 6.4, 3.3, 2.5, and 1.4 % of the catch, respectively. Atlantic needlefish *Strongylura marina*, gizzard shad, channel catfish *Ictalurus punctatus*, white catfish *Ictalurus catus*, white perch *Morone americana*, and striped bass *Morone saxatilis* were also captured, but comprised less than 1% of the total catch. The vast majority of fish (85.5%) were captured in the floating as compared to the mid-water gill net. Length at date of American shad (Figure 1) and blueback herring (Figure 2) was similar in 2013 and 2014, though each species was larger earlier in the season during 2014.

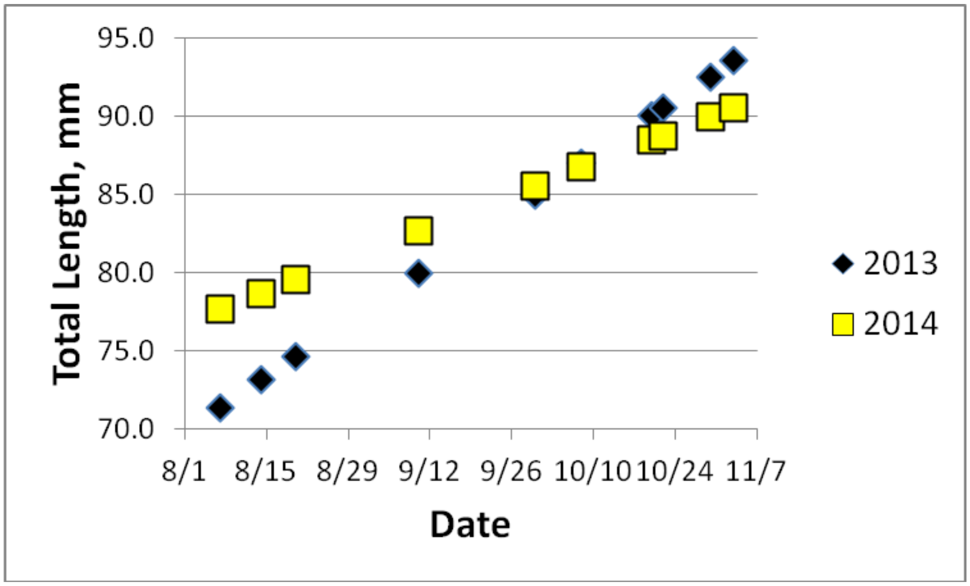

Figure 1. Length at date of young-of-year American shad in Lakes Marion and Moultire, as determined by liner regression.

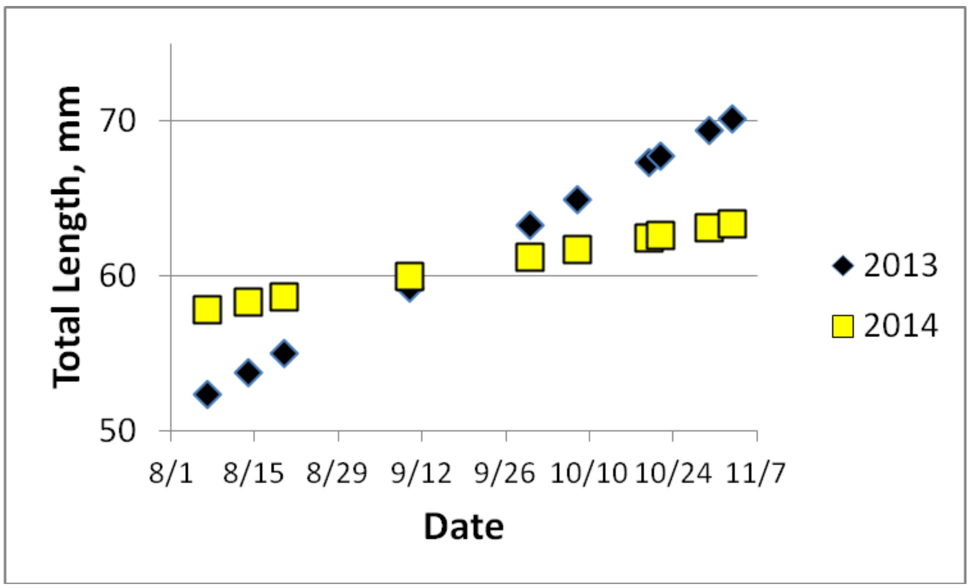

Figure 2. Length at date of young-of-year blueback herring in Lakes Marion and Moultrie as determined by linear regression.

Recommendations

1. Continue with hydroacoustic sampling in summer and fall of 2015 using the identical method used in 2014.
2. Complete processing of 2013 through 2015 hydroacoustic and gill net data so that a final report can be completed by September 30, 2016.

.

Prepared By: James Bulak Title: Research Coordinator - Freshwater Fisheries

Job Title: Great Pee Dee River Striped Bass

Period Covered July 1, 2014 - June 30, 2015

Summary

In the study year, 59 striped bass *Morone saxatilis* were collected from the Great Pee Dee River for genetic analysis of population stock structure; genetic analysis is in progress. Also, two additional adult striped bass received transmitters so that annual movements can be better understood.

Introduction

The Great Pee Dee River supports a population of striped bass. Little is currently known about the size, genetic make-up, or behavior of this species in this river system. Additional information was needed so that future management endeavors can develop appropriate procedures aimed at enhancing the population. The overall objectives of this work were to obtain a representative sample of striped bass for genetic characterization and transmit several adult fish to assess seasonal movement patterns. In a prior period, genetic samples of striped bass were obtained from the upper reaches of the river; in this period, emphasis was placed on obtaining samples from the mid and downstream reaches of the river.

Materials and Methods

Boat electrofishing was the chosen method to collect adult striped bass from the Great Pee Dee River. Efforts in the mid-river area concentrated around the Cashua Ferry boat landing, Darlington County, approximately 190 km upstream of the U.S. Highway 17 bridge crossing. Efforts in the down-river area concentrated around Yauhannah boat landing, at the 701 bridge crossing, Horry County, approximately 70 km upstream of the U.S. Highway 17 bridge crossing. Also, we assisted with multi-agency efforts to collect robust redhorse *Moxostoma robustum* from the North Carolina portion (i.e. upstream area) of the Great Pee Dee River, collecting striped bass as they appeared.

Fin clips were taken from all collected striped bass for microsatellite genetic analysis. The fin clips were stored in vials containing sarcosyl urea and sent to the genetics lab at the Marine Division, SC Department of Natural Resources, for analysis.

Efforts were made to surgically implant striped bass with Vemco acoustic transmitters, taking advantage of the 58 remote Vemco receivers currently deployed in the Great Pee Dee River to determine sturgeon movements. These receivers covered the entire Pee Dee system, from the Highway 17 bridge in Georgetown (designated as river km 0.0) to Cheraw, SC (river kilometer 301). Receivers were also located in Winyah Bay, downstream of the Highway 17 bridge and in the Waccamaw River; locations in these sites were given negative river kilometer designations to denote approximate distance from the Highway 17 bridge. Receivers were downloaded periodically and the location of each transmitted fish, by date and time of day, was recorded.

Results and Discussion.

A total of 57 striped bass were obtained from the Great Pee Dee River during the study period; of these, 19, 8, and 30 were obtained from upper, middle, and lower reaches of the river. Genetic samples were obtained from all specimens and delivered to the genetics lab at the Marine Division for processing; genetic analysis of these samples was not completed during the study period.

Two additional striped bass were fitted with acoustic transmitters. Both were collected and released in the vicinity of the Yauhannah boat landing at Highway 701. One fish, 521 mm TL, was transmitted on April 9 while the second fish, 662 mm TL, was transmitted on May 6. A striped bass transmitted in the North Carolina portion of the river on May 16, 2013 was harvested by an angler and the transmitter returned during December of 2014. All remote receivers were periodically downloaded and subsequently archived during the study period. Processing of downloaded data was not completed during the study period.

Recommendations

1. Complete genetic assessment of the study year samples and attempt to define the stock structure of Great Pee Dee River striped bass. Once results are obtained, decide whether additional samples are needed.
2. Complete the assessment of the movement patterns of striped bass transmitted in the current and prior study period. If possible, implant the remaining transmitters into striped bass from mid and downstream reaches, taking advantage of the Vemco receiver network.

Prepared By: James Bulak Title: Research Coordinator - Freshwater Fisheries

Job Title: Condition of Stocked Striped Bass

Period Covered July 1, 2014 - June 30, 2015

Summary

A sample of 518 individual fish from all batches of striped bass *Morone saxatilis* stocked into the Santee-Cooper lakes in 2014 was measured and weighed to assess relative condition of stocked fish. Fish stocked in 2014 had a lower relative condition than those stocked in 2011 or 2012, the other two years for which similar data are available. Future work will combine and assess the three years of data.

Introduction

The stocking of striped bass is an important fishery management activity for the state's waters. Most South Carolina reservoirs depend on hatchery stocking of striped bass as natural reproduction is not possible. In the Santee-Cooper system, which includes Lakes Marion and Moultrie, natural reproduction does occur; however, stocking is used to augment natural reproduction, which exhibits high annual variability.

Somewhat surprisingly, the success of stocking striped bass in the Santee-Cooper system has also exhibited high annual variability. The reasons behind this variable annual survival are not well understood and need further inquiry.

The objective of this study was to investigate the condition of striped bass stocked in 2014. The stockings of 2011 and 2012 have previously been evaluated. Once the 2014 is complete, a combined analysis of the three years of evaluation will be performed, inspecting differences in condition and whether observed differences relate to survival of hatchery fish.

Materials and Methods

In 2014, a sample of approximately 20 striped bass was taken from each stocking batch going into Lakes Marion and Moultrie (a batch is defined as those fish used to fulfill an individual, unique stocking event; a batch was generally composed of a single genetic family, although that same family may fulfill several stocking batches). The sampled fish were immediately frozen. At a later time, these samples were defrosted and total length (mm) and wet weight (g) were determined. Wet weight samples were placed on a paper towel prior to weighing to remove excess moisture. The samples were then dried at 60 °C for at least 48 hours and dry weight (g) was measured.

Relative condition factor (K) was calculated for each fish as:

$$K = W_{obs}/W_{pred}$$

Where W_{obs} is the observed weight of an individual fish and W_{pred} is the length-specific predicted weight, as predicted by a length-weight equation. Length weight relations determined for 2011 stocked fish were used to define the predicted wet and dry weights; the equations were:

$$\text{Log}_{10} \text{ wet weight (mg)} = -2.54 + (3.35 * \log_{10} \text{ total length, mm}),$$

$$\text{Log}_{10} \text{ dry weight (mg)} = -3.48 + (3.54 * \log_{10} \text{ total length, mm}).$$

Relative condition factors were generated for observed wet and dry weight. We then defined the average relative condition factor for each stocking batch. A preliminary assessment of the effects of family, date of stocking, and rearing pond on condition was performed for fish reared at Dennis Center.

Results and Discussion

In the study year, a total of 519 individual fish were measured, and weighed from a total of 26 different stocking batches from 6 distinct stocking families. Stocking began on May 14, 2014 and ended on May 27, 2014. Overall relative condition was 0.91 (standard deviation = 0.14) and 0.94 (standard deviation = 0.13) for wet and dry weight measurements, respectively, suggesting a lower overall condition of stocked fish than observed in 2011 and 2012.

Recommendations

1. Combine and assess data from the three study years, 2011, 2012, and 2014, inspecting for differences in condition due to time of stocking, pond, family, and year.
2. Relate age-2 survival information (obtained from genetic analysis of gill net monitoring data) to condition data to discern if there is a relationship.
3. Produce Final Report.

Prepared By: James Bulak Title: Research Coordinator - Freshwater Fisheries

Job Title: Lake Hartwell Habitat Evaluation

Period Covered July 1, 2014 - June 30, 2015

Summary

A pilot study employing telemetry and mark and recapture methods was conducted to evaluate the potential of obtaining a population estimate of catchable largemouth bass *Micropterus salmoides* from an embayment of Lake Hartwell. Telemetry demonstrated that the vast majority of fish remained on the shoreline and were vulnerable to electrofishing during the study period; migration from the study embayment was estimated and was relatively minor. Mark and recapture sampling yielded 137 catchable largemouth bass over four sampling days. A preliminary population estimate of 230 catchable (>304 mm TL) bass was obtained.

Introduction

Lake Hartwell, impounded in 1963, is a 22,600 hectare U.S. Army Corps of Engineers reservoir located in the Savannah River basin. The presence of polychlorinated biphenyls (PCB) in the Twelve Mile Creek arm of Lake Hartwell was discovered in the 1970s; this led to a legal action and, eventually, a monetary settlement with the plaintiffs by the responsible party. South Carolina elected to use a part of these settlement monies to enhance the habitat of Lake Hartwell, which is done by placing various structures (such as fallen trees, gravel beds, and root wads) in the reservoir. Habitat placement occurs to enhance angler success and the local biological production potential. However, it is not clear how much increase in biological production will occur as a result of habitat placement. Thus, the objective was to conduct a pilot study to assess whether the population size of catchable largemouth bass could be determined in a habitat-treated embayment of Lake Hartwell.

Materials and Methods.

The chosen study site was a 37 hectare embayment (i.e. the 'Cherry Cove') located adjacent to Clemson University, Clemson, SC, at 34.6524° x -82.831955°. This study site had received habitat enhancement the prior year, had good access, and was typical of the type of area that is expected to be treated in the future.

A strategy that combined a traditional mark and recapture approach with telemetry was chosen. Mark and recapture was expected to provide a population estimate with a reasonable degree of statistical certainly. Telemetry was used to assess migration and define the portion of the population that was vulnerable to the chosen sampling gear, boat electrofishing. The central portions of the Cherry Cove range in depth from 2.4 to 10.7 m, which is too deep for effective boat electrofishing.

Ten largemouth bass were captured with boat-mounted electrofishing equipment from the Cherry Cove on 18 March 2015 and implanted with ultrasonic transmitters. Fish were implanted 26 days before the mark recapture survey to allow them to recover from handling associated stress. Three different models of individually coded transmitters manufactured by Sonotronics, Inc. (Tucson, Arizona) were used. Largemouth bass ≤ 330 mm TL were implanted with IBDT-96-2 transmitters, largemouth bass > 330 mm TL were implanted with CT-82-1 transmitters, and two fish were implanted with depth sensing transmitters (IBDT-96-6). All transmitters had an advertised battery life >59 d. Transmitter weight was less than 2% of fish weight estimated from largemouth bass length weight relationships for Lake Hartwell.

When largemouth bass were captured they were immediately placed on a large v-trough measuring board, covered with wet towels, and measured (TL mm). Ultrasonic transmitters were inserted through a 30 mm incision posterior to the right ventral fin. Incisions were closed with two or three interrupted absorbable sutures (2-0 Maxon; Tyco Health Care). No chemical anesthesia was used; the fish were sufficiently sedated by electrofishing for the short (<120 sec) implantation procedure.

Transmitter-implanted largemouth bass were monitored with an acoustic receiver array and by manual tracking. Eight acoustic receivers (SUR3BT, Sonotronics, Inc., Tucson, Arizona) were placed within the study cove to monitor largemouth bass persistence in the cove. Largemouth bass were manually located by boat during the daytime using a scanning receiver and hydrophone (USR08, Sonotronics, Inc., Tucson, Arizona), to determine whether or not they occupied the shoreline and as such were in water depths (< 2.4 m) vulnerable to electrofishing. Once fish were located their depths and positions were recorded. Depths were recorded from the onboard depth finder.

Largemouth bass > 304 mm TL were captured along the shoreline of Cherry Cove using boat electrofishing. At the first sampling event, length and weight were measured and a uniquely-numbered PIT tag was inserted into the abdominal cavity. On subsequent sampling trips, the same protocol was followed and each captured fish was checked for the presence of a PIT tag using a portable detector.

A dynamic occupancy formation of individual capture histories combined with a data augmentation technique (Kéry and Schaub 2012; Royle and Dorazio 2012) was used to estimate the population size of catchable largemouth bass. Telemetry data was used to assess the proportion of the population that was within shoreline habitat and the amount of migration out of or into the cove, both of which influenced the vulnerability of tagged fish to the sampling effort and, thus, the accuracy of the population estimate.

Results and Discussion

Manual tracking of ten transmitted largemouth bass was conducted on four days between April 7 and 22, 2015, to coincide with mark-recapture surveys (April 14-23, 2015). Apparently, 8 of 10 fish were in the Cherry Cove at the start of manual tracking on April 7 (Table 1). Twenty-six (26) of 27 manual tracking observations (96%) of transmitted largemouth bass were made in the shoreline zone, where the fish were vulnerable to electrofishing (Table 1).

Table 1. Manual tracking results for transmitted largemouth bass on a Lake Hartwell cove in 2015. Fish were classified as 'on' if they were along the shoreline in water < 2.4 m in depth and 'off' if they were in off-shoreline habitat > 2.4 m in depth.

Fish ID	April 7	April 8	April 13	April 22
2	on	on	on	on
3	on	on	on	on
4	on	.	on	**off**
6	on	on	on	.
7	on	on	on	on
9	on	.	.	.
10	on	on	on	on
11	on	on	on	on

At the beginning of the mark-recapture experiment (14 April) seven largemouth bass were detected within the cove with the receiver array. Six of those fish remained in the cove throughout the entire mark-recapture experiment and one fish (ID 6) left the cove on 18 April and did not return during the experiment. The initial estimate of emigration of transmitter-implanted largemouth bass during the mark-recapture experiment was 7%. However, downloading and processing of all data from all receivers was not completed during the study year.

During mark-recapture sampling, 137 unique individuals of catchable largemouth bass (> 300 mm in TL) were captured over four sampling occasions. The population size of catchable largemouth bass in the shoreline habitat was estimated at 230 individuals (95% Credible Interval (CI): 170-294). Detection probability differed by sampling occasion: 0.23 (95% CI: 0.16-0.34) on Day 1, 0.10 (95% CI: 0.06-0.15) on Day 2, 0.27 (95% CI: 0.18-0.37) on Day 3, and 0.20 (95% CI: 0.15-0.28) on Day 4. The low detection probability on Day 2 reflected incomplete sampling due to an equipment failure. Individuals stayed in the shoreline habitat between two consecutive tracking occasions with a probability of 0.93 (95% CI: 0.82-0.99). Final analysis of remote receiver data is needed to confirm this estimate.

This pilot study indicated that population estimation of catchable largemouth bass in Lake Hartwell coves was feasible. Based on the experience gained in 2015, some minor modifications in strategy are needed to increase the efficiency and accuracy of future efforts, which should initially concentrate on non-enhanced coves to establish a baseline of largemouth bass abundance. For example, some transmitted fish should be captured from off-shore habitat > 2.4 m in depth to help insure that the transmitted population is representative of the whole population.

Recommendations

1. Finalize the 2015 population estimate of the Cherry Cove and either publish or present results at an upcoming scientific meeting.
2. Using 2015 results and experience identify a work strategy for 2016 that maximizes accuracy and efficiency.
3. Plan to conduct telemetry and mark/recapture evaluation in at least one, preferably two, non-habitat-enhanced Lake Hartwell coves in 2016.

Literature Cited

Royle, J. A., and R. M. Dorazio. 2012. Parameter-expanded data augmentation for Bayesian analysis of capture-recapture models. Journal of Ornithology 152:S521-537.

Kéry, M., and M. Schaub. 2012. Bayesian population analysis using WinBUGS: A hierarchical perspective. Elsevier, New York.

Prepared By: James Bulak Title: Research Coordinator - Freshwater Fisheries

Job Title: Development of a Population Monitoring Plan for Broad River Smallmouth Bass

Period Covered July 1, 2014 – June 30, 2015

Summary

During 2015 we continued our evaluation of multiple pass depletion sampling as a method to estimate density and biomass of smallmouth bass *Micropterus dolomieu* in the Broad River. Twenty-three (23) hours of electrofishing effort were expended during two electrofishing passes at each of two sample sites. At the two sites 113 smallmouth bass and 36 largemouth bass *Micropterus salmoides* were collected with a combined weight of 20.4 kg. We were not successful depleting smallmouth bass or largemouth bass within the sample reaches with multiple pass depletion sampling and consequently unable to produce reliable density and biomass estimates. Multiple pass depletion sampling does not appear to be a viable method with current resources and therefore we began evaluating mark-recapture methods for determining smallmouth bass density and biomass.

Introduction

A thriving fishery for smallmouth bass exists in the Broad River; however, due to poor river access, poor capture efficiency, and difficult navigation a suitable method to assess smallmouth bass abundance and population structure has not been developed. During 2015 we continued our evaluation of multiple pass depletion sampling and initiated an evaluation of mark-recapture techniques, in collaboration with Clemson University, as potential standard sampling techniques to evaluate smallmouth bass density, biomass, and population structure.

Materials and Methods

Multiple pass depletion sampling was conducted at two sites during late September 2015. The Shelton Ferry site (1,400 m long and 125 m wide) began just above Henderson Island (34.482339, -81.422734) and ended at the Tyger River confluence (34.494867, -81.423318). The Chestnut Hill site (1,053 m long and 129 m wide) ended at the Chestnut Hill Subdivision boat ramp (34.125057, -81.134091) north of Columbia, SC. At each site five electrofishing boats were spaced evenly across the river. Electrofishing was conducted continuously from the beginning to the end of the site and all *Micropterus* species encountered were collected. At the end of each pass fish were sorted by species, measured for Total Length (TL, mm), weighed (g), and then placed in an oxygenated tank until the final pass was completed. After all sampling was completed the fish were released back into the sample reach.

A new study, in collaboration with Clemson University, was initiated to evaluate the utility of mark recapture methods to estimate density and biomass of adult smallmouth bass in the Broad River. To satisfy the no immigration or emigration assumption of marked and unmarked animals into or out of the study reach a radio telemetry study was initiated. During May 2015 smallmouth bass captured with boat electrofishing gear from the river section below 99-Islands Reservoir were implanted with radio transmitters (ATS F1580, Advanced Telemetry Systems, Isanti, MN).

Results and Discussion

Two electrofishing passes were completed at each site with a total sampling effort of 23.2 hours (10.4 hours at Chestnut Hills and 12.8 hours at Shelton Ferry). A total of 36 largemouth bass and 113 smallmouth bass were collected at the two sites (Table 1). Catch per unit effort of Age-1 and older smallmouth bass was very low at each site (0.48 and 0.65 fish/hour). The majority (87%)

of smallmouth bass collected were young-of-the-year fish (67 – 144 mm TL). Sampling was terminated after two passes at each site due to the low catch rates of Age-1 and older smallmouth bass. Overall Mean TL of largemouth bass was 228 mm TL (range; 75 – 481 mm TL) and overall mean TL of smallmouth bass was 133 mm TL (range; 67 – 466 mm TL). Average weight was 321 g for largemouth bass and 79 g for smallmouth bass. At the Shelton Ferry site one redeye bass *M. Coosae*, one Alabama bass *M. henshalli*, and one hybrid among *Micropterus sp*. were collected.

Table 1. Electrofishing site, pass number, number collected (N), mean total length (TL, mm) and weight (g), with range in parentheses, and number of young-of-the-year (YOY) smallmouth bass for largemouth bass and smallmouth bass collected during 2014 from the Broad River, South Carolina with multi pass electrofishing.

		Largemouth Bass			Smallmouth Bass			
Site	Pass	N	Mean TL (mm)	Mean Wt (g)	N	Mean TL (mm)	Mean Wt (g)	YOY
Chestnut Hill	1	10	332 (202-423)	519 (84-974)	15	124 (76-367)	91 (5-711)	12
Chestnut Hill	2	19	156 (75-404)	140 (5-823)	28	110 (67-389)	57 (5-700)	26
Shelton Ferry	1	4	382 (268-481)	900 (239-1712)	36	141 (94-466)	86 (10-1410)	32
Shelton Ferry	2	3	132 (90-216)	39 (7-102)	34	148 (95-348)	83 (10-558)	28
All	All	36	228 (75-481)	321 (5-1712)	113	133 (67-466)	79 (5-1410)	98

Multiple pass depletion sampling was not successful at estimating abundance or biomass of *Micropterus sp* in the Broad River during 2013 or 2014. The sample sites were likely too large to successfully deplete the *Micropterus* population with available resources. Unless significantly more resources become available multiple pass depletion does not appear to be a viable tool to assess smallmouth bass abundance and population structure. The method may work in narrower sections of the river, where channel width is constricted by islands; however, these areas are few in number and very difficult to access.

During May 2015, 14 smallmouth bass (Mean TL = 358 mm, range 283 – 482 mm TL) captured with boat electrofishing gear from the river section below 99-Islands Reservoir were implanted with radio transmitters (ATS F1580, Advanced Telemetry Systems, Isanti, MN). Transmitter-implanted smallmouth bass were located twice each month during May and June 2015 to determine their persistence in the study reach. All transmitted individuals remained in the study reach and displacement between locations for individual fish was < 100 m. The low dispersal of transmitter-implanted smallmouth bass during the first two months of tracking indicated that fish will remain within the study reach during the mark-recapture experiment.

Recommendations

1. Discontinue multiple pass depletion sampling of smallmouth bass.
2. Continue with the evaluation of mark-recapture techniques to assess smallmouth bass abundance and size distribution in the Broad River. The first mark recapture experiment will be conducted during fall 2015 and we will continue to monitor transmitter-implanted smallmouth bass movements through summer 2016.

Prepared By: Jason Bettinger Title: Wildlife Biologist

Job Title: SC Small River Conservation Planning Project

Period Covered October 1, 2014 – September 30, 2015

Summary

Over the reporting period, the first year of the project, we established a sampling design to assess small rivers across the state of South Carolina, intended to further the goals of the Stream Assessment completed in 2012. Several sampling gears for collecting fishes were evaluated with respect to efficiency and level of effort necessary to characterize fish species richness and fish abundance. Continued work on species detection and subsequent fieldwork to assess small rivers is recommended.

Introduction

In South Carolina, high quality aquatic habitats support a rich fauna. The rivers and streams of the southeastern United States have the highest known diversity of mussels, snails and crayfishes in the world. In addition, freshwater fish species richness is the highest of any temperate region and the herpetofauna is globally significant. South Carolina's State Wildlife Action Plan (SWAP) contains descriptions of over 125 species of fish, herpetofauna, mussels, crayfish and snails that are directly dependent on freshwater habitats for most or all of their life-stages, accounting for approximately 40% of the state's total number of species of conservation concern (excluding marine species). The Draft 2015 State Wildlife Action Plan (SWAP) lists 170 species (including leeches, insects, and additional species from the above listed taxa).

This project fits into a grand vision of aquatic conservation in South Carolina that focuses on landscapes and their drainage basins. Water, running off the land and coursing through streams and rivers, integrates landscapes due to the linear, connected nature of drainage networks. Simply put, tiny headwater streams join to form larger and larger channels, which combine to form the major rivers. Downstream habitats, including the reservoirs, estuaries, and coastal systems of the state, are directly influenced by upstream network conditions. Our SWAP describes the environmental changes taking place across South Carolina's freshwater landscape that negatively affect native fauna, generally involving siltation, altered hydrology, contaminants, and other forms of habitat degradation. A landscape approach allows us to proactively address cumulative impacts to ecological integrity, integrated across taxa and geography. We can address the needs of all priority species that depend on aquatic systems by building a true mountain-to-the-sea, headwater-to-estuary framework for conservation.

The first step in building this conservation framework has been largely completed. Through previous State Wildlife Grants, small wadeable streams were assessed during the South Carolina Stream Assessment (SCSA). Data were entered into the StreamWeb database and information served in a web-accessible Stream Conservation Planning Tool. One result apparent from those data is the increase in species richness with stream size, up to the upper size limit in the sample design, which indicates that roughly one species can be expected to be added with every 10 km2 increase in stream drainage area. It also suggests that a major repository of fish diversity in the state resides in larger streams and small rivers.

The Small River Assessment is intended to extend and further the objectives of the South Carolina Stream Assessment, which was limited to wadeable streams under 150 km2 in drainage area, in order to include the greater spatial extent of small rivers (up to 2,000 km^2). In Year One of the project, we addressed two objectives: 1) Design a sampling program that will define the physical, chemical, and biological conditions in small rivers across South Carolina; 2) Develop a sampling protocol appropriate for assessing physical and biological characteristics of small rivers across the range of settings in South Carolina and evaluate any sampling gear bias that may affect species and individual detection probabilities; 3) Evaluate the optimal response variables (e.g. species presence/absence, population abundance and species richness)

Materials and Methods

Sampling Design

A database listing the spatial coordinates and area drained for all 100 m long segments of every stream and river in South Carolina, compiled for the Stream Assessment project, was used to create a list frame of potential sites from which to select sites for the Small River Assessment. To be included in the list frame, sites had to have a drainage area between 150 and 2000km^2. Sites were stratified by major river drainage and ecoregion (=ecobasin) and by size (=drainage area). The number of sites apportioned to each strata was proportional to ecobasin area and drainage area, with three size categories defined: Class 4 – 150 to 700 km^2, Class 5 – 700 to 1400 km^2, and Class 6 – 1400 to 2000 km^2.

Sampling protocols

Small rivers, in between wadeable streams and large rivers, pose challenges for estimating fish assemblage richness and abundance because appropriate methods may vary considerably by site conditions. We collected fish data using several standard methods (Bonar et al. 2009) in these habitats that are being used to evaluate gear bias and estimate species detection probabilities, with the goal of developing biological estimates that can be compared across the state. Gears employed during the reporting period included backpack electrofishing with seine, bag seine hauls, and gill nets. In each case, repeated collection efforts were made within a one month period and subsamples compared with the pooled total to assist in establishing appropriate assessment protocols.

The first gear evaluated was backpack electrofishing downstream into a set seine, suitable for shallow (wadeable) habitats with fast or slow flow velocities. The same location (spanning 200-300 linear m) was visited on three separate occasions, and on each occasion 50 separate seine sets were conducted. A set comprised deploying a 3.05m (10ft) seine on the substrate while a backpack electrofisher was deployed just upstream and approached the seine while kicking the substrate, covering an area approximately $12m^2$. Fishes from each set were identified and enumerated into 3 cm size class bins.

The second gear independently evaluated was the 6.1m (20ft) bag seine haul method, targeting shallow, slow velocity habitats. At a different location than backpack electrofishing, 33 seine hauls were pulled on each of three separate occasions, spanning approximately 500 linear m. Fishes from each set were identified and enumerated into 3 cm size class bins.

Finally, gill nets were deployed in deep, slow velocity habitats. Various deployment times were assessed, from 2 to 6 hrs. Considerable time and effort was spent attempting to evaluate gill nets on the Saluda River near Greenville, but only a handful of fish were collected there. The nets were then deployed in Twelvemile Creek with more success, although water depth limited the available habitat for gill nets.

Response variables

Data collected in Year 1 have been entered into electronic data files and analysis has been initiated with collaborators from Clemson University to examine species presence/absence, species abundance, assemblage structure, and species richness to determine the appropriate level of data aggregation to provide robust response variables in the project. In the reporting period, results from species richness and individual species abundance are available. Due to the low number of fish collected with gill net in Year One, only backpack electrofishing/seine sets (hereafter referred to as sets) and bag seine hauls (hauls) were analyzed.

Species accumulation curves were constructed from the results of the two gears separately to provide a visual aide in assessing results in detecting species at increasing levels of effort, with “true” richness represented by pooling (by gear) all sets on all occasions. Species accumulation curves were created for each sampling occasion using the vegan package in Program R with the “specaccum” function (R Core Team 2012). Each curve was generated with 100 permutations where the function added spatial replicates (sets or hauls) at random. A mean curve was generated with 95% confidence intervals.

Estimates of variance in individual species abundance were investigated using mixed models. A generalized linear mixed-effects model was created for each species to investigate variance across temporal (sampling occasions) and spatial replicates (sets or hauls). Occasion and set/haul number were added as a random effect on the intercept to obtain variance information.

Results & Discussion

Sampling Design

The locations of potential small river assessment sites are mapped in Figure 1. There were 3,543 linear km of small river habitat located in the state from which to select samples. These rivers are further broken down by ecobasin and size class strata according to area drained (Table 1).

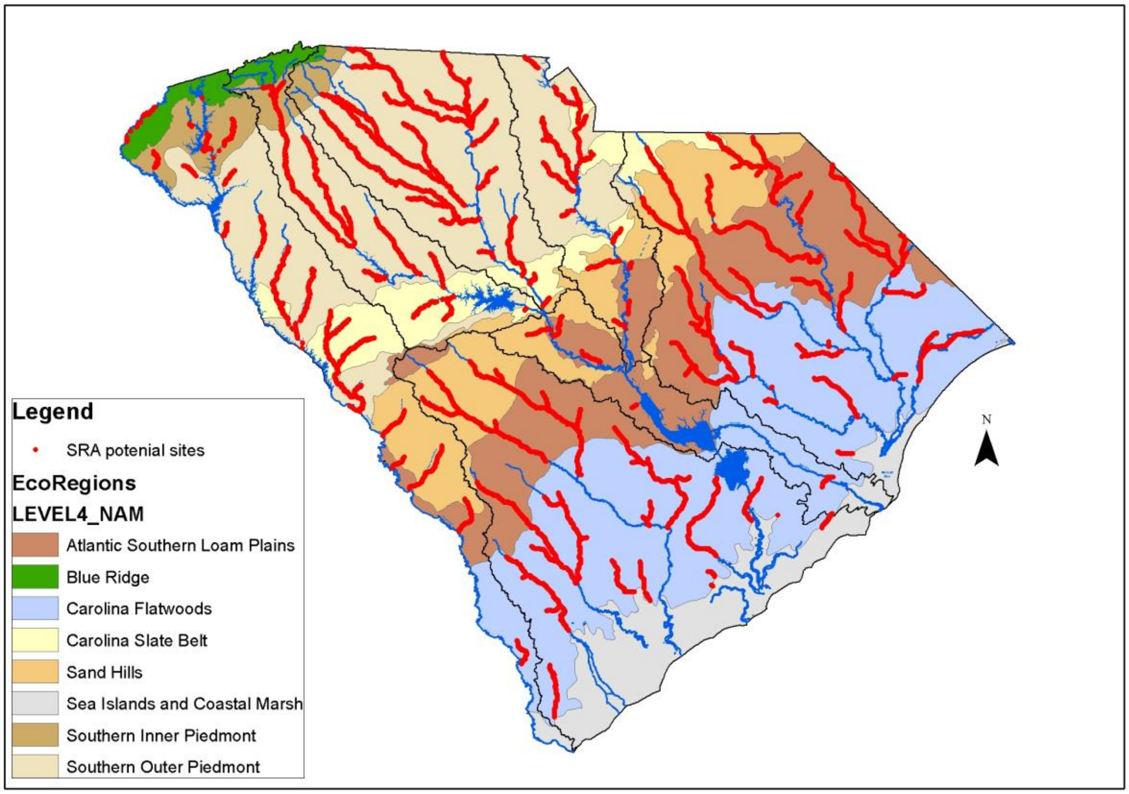

Figure 1. Occurrence of small rivers in South Carolina, defined as draining between 150 and 2000km^2 in area, are depicted in red.

Table 1. Breakdown of sample site allocations according to ecobasin (prefixes as follows: SAV-Savannah, SAL-Saluda, BR-Broad, CW-Catawba-Wateree, LS-Lower Santee, PD-Pee Dee) and river size class (Class 4: 150 to 700 km^2, Class 5: 700 to 1400 km^2, Class 6: 1400 to 2000 km^2 drainage).

Ecobasin	Drainage Area (km^2)	*n total*	*Class 4*	*Class 5*	*Class 6*
SAVUPL	8,180	12	6	5	1
SALUPL	6,303	9	6	2	1
BRUPL	9,707	14	9	4	1
CWUPL	4,168	6	4	2	0
PDUPL	711	3	3	0	0
Upland	29,069	44			
SAVSEP	2,555	4	4	0	0
ACESEP	5,686	8	5	2	1
LSSEP	5,149	7	7	0	0
PDSEP	10,210	14	9	3	2
Southeastern Plains	23,600	33			
SAVFLATW	849	3	3	0	0
ACEFLATW	10,637	15	9	5	1
LSFLATW	1,589	3	3	0	0
PDFLATW	8,805	12	9	2	1
Mid Atlantic Coastal Plains	21,880	33			
Total	**74,549**	**110**			

Sampling protocols

Three gear types were deployed during the reporting period, targeting particular mesohabitats (Table 2). Table 2 also lists species that were collected with each gear along with the size range (cm) of fish encountered.

Table 2. Total length (cm) ranges of fish species collected by three standard gear types and methods on two upland pilot rivers, Twelvemile Creek (seine + backpack electrofishing, bag seine, gillnet) and Saluda River (gillnet). Mesohabitat type abbreviations are as follows: SF = shallow/fast; SS = shallow/slow; DS = deep/slow.

	Gear Type		
	Seine (10') Sets Backpack EF	**Bag Seine (20') Hauls**	**Gill Net (L=30'; mesh 0.5"-2.5"-0.5")**
Mesohabitat Type	SF, SS,	SS	DS
Catostomidae			
Quillback		3 — 15	42 — 45
Highfin Carpsucker		6 — 9	28 — 39
Northern Hog Sucker	2 — 27	3 — 9	
Spotted Sucker		9 — 12	
Notchlip Redhorse	27 — 30		
Striped Jumprock	18 — 21		
Centrarchidae			
Redbreast Sunfish	6 — 18		
Green Sunfish	6 — 15		
Warmouth	12 — 15		
Bluegill	3 — 15	2 — 18	
Redear Sunfish		6 — 18	
Redeye Bass	9 — 21	6 — 9	9 — 12
Largemouth Bass	9 — 12	6 — 36	
Hybrid Black Bass		9 — 15	
Black Crappie		18 — 21	
Cyprinidae			
Whitefin Shiner	3 — 12	2 — 12	9 — 12
Eastern Silvery Minnow		3 — 15	
Rosyface Chub	6 — 12	3 — 9	
Bluehead Chub	3 — 21	3 — 6	
Golden Shiner		6 — 9	
Spottail Shiner	9 — 12	2 — 12	9 — 12
Yellowfin Shiner	3 — 12		
Ictaluridae			
Snail Bullhead	3 — 30		
Flat Bullhead	3 — 24		
Channel Catfish			51 — 54
Margined Madtom	3 — 15		
Lepisosteidae			
Longnose Gar			78 — 81
Percidae			
Turquoise Darter	3 — 12	3 — 6	
Blackbanded Darter	3 — 12	3 — 6	
Poeciliidae			
Eastern Mosquitofish		2 — 6	

Response variables

Species accumulation curves for sets indicated that there was fairly high variance among sets but not among occasions (Figure 2). Fifty sets achieved 90% of species in the reach only on the first occasion, whereas successive occasions reached 79% and 74%. Species curves appeared to flatten between 10 and 20 sets, suggesting an optimal effort unless a goal is to effectively capture rare species. Variance in individual species abundance estimated by mixed models showed high variance across sets for a number of species, and as with richness had lower variance across occasions (Table 3.). The influence of rare species is strong here also, as fishes that were present during only one occasion could not be estimated by the model, and the highest variances corresponded to the least abundant species.

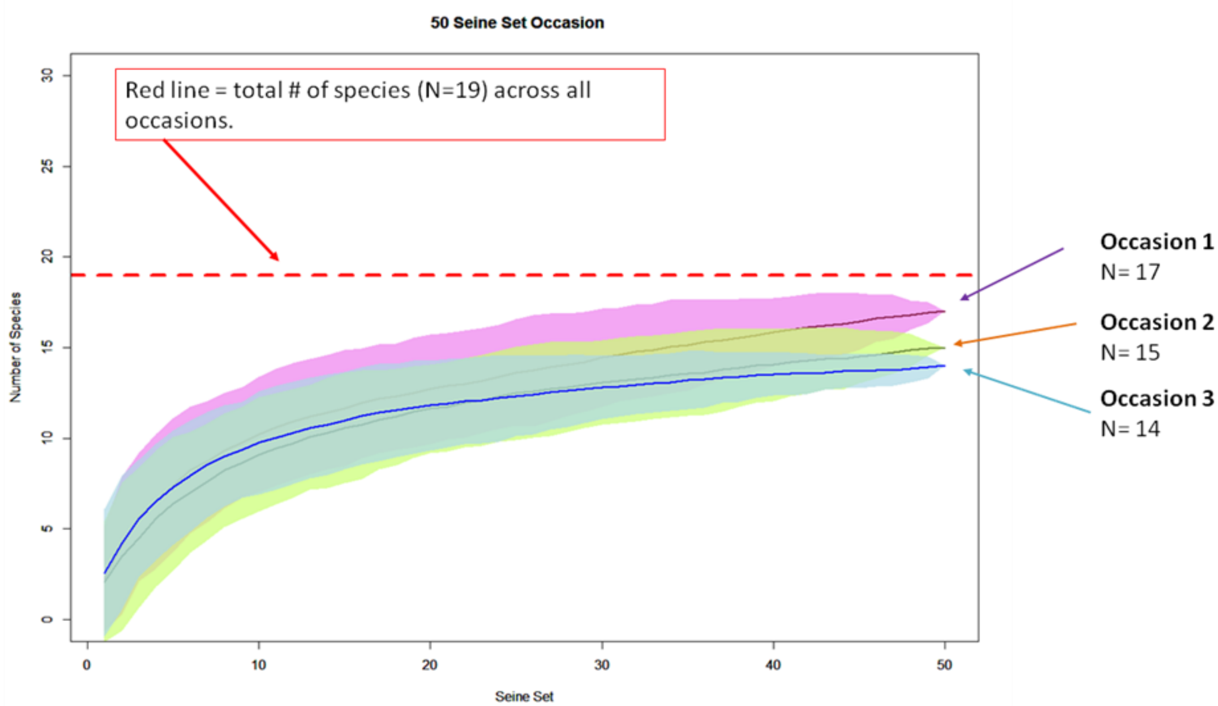

Figure 2. Species accumulation curves calculated from 50 seine sets with backpack electrofishing on three separate occasions at the same location.

Table 3. Variance in abundance of individual species from 50 seine sets with backpack electrofishing on three separate occasions, estimated with mixed models.

Species	**Occasion Variance**	**Set Variance**
BBD	0.029	0.504
BHC	0.249	2.754
BLG	0 .000	11.840
GSF	53.890	149.820
MGM	0.070	5.026
NHS	0.035	1.159
RBS	0 .000	5.816
REB	0 .000	33.490
RFC	0.127	24.514
SBH	0 .000	1.333
STJ	0.000	82.540
TQD	0.191	19.581
WFS	0.018	2.747
YFS	0.178	2.697

For bag seine hauls, species accumulation curves suggested that this gear was less efficient than the sets, with successive occasions collecting 78%, 61%, and 39% of pooled species richness (Figure 3). Variance in individual species abundance showed high variance across sets and high variance for several species across occasions (Table 4). Bag seine hauls did suffer, however, from the fact that occasions spanned a full month from mid-October to mid-November (due to rain events) and underwent significant flow variation and temperature differences over this period. In comparison, set gear spanned only 3 weeks in May-June with much less environmental variation.

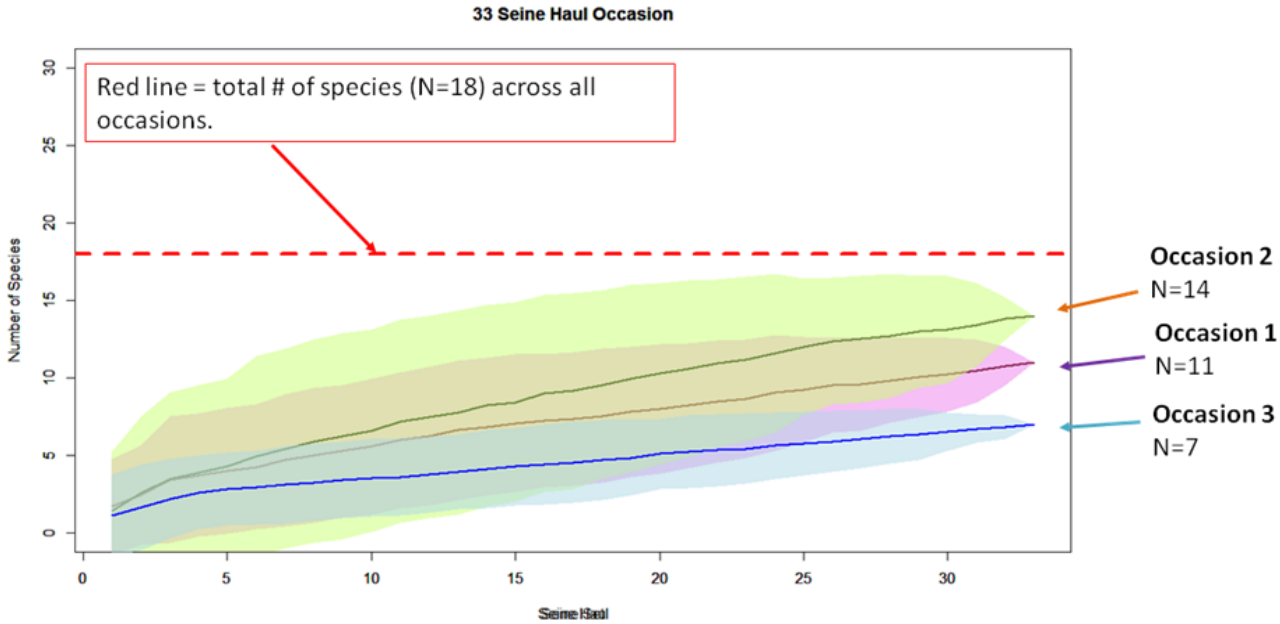

Figure 3. Species accumulation curves calculated from 33 bag seine hauls on three separate occasions at the same location.

Table 4. Variance in abundance of individual species from 33 bag seine hauls on three separate occasions, estimated with mixed models.

Species	Occasion Variance	Set Variance
BLG	5.583	91.452
ESM	1.158	16.564
LMB	2.148	98.852
NHS	0.062	19.926
QLB	3.448	58.282
RES	7.651	153.852
RFC	162.400	217.500
SPS	137.600	188.600
STS	0.004	2.726
WFS	0.098	1.360

Recommendations

This report covers Year One of a three year grant; we recommend the project continue as outlined in the proposal.

Literature Cited

Bonar, S.A., W.A. Hubert, and D.W. Willis, eds. 2009. Standard Methods for Sampling North American Freshwater Fishes. 335 pages. American Fisheries Society, Bethesday, MD.

R Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Prepared By: Mark Scott, Kevin Kubach, Drew Gelder, Kenson Kanczuzewski

Title: Wildlife Biologists

Job Title:	Development and implementation of an environmental DNA (eDNA) monitoring tool for Blackbanded Sunfish populations in South Carolina and Georgia with determination of relative abundance, genetic health, and connectivity of extant populations
Period Covered	October 1, 2014 – September 30, 2015

Summary

As part of a Multi-state SWG project Year One activities, we developed sampling site selection criteria, produced a list of potential sample sites, established habitat assessment protocols, and conducted field collections of water samples and habitat data. These statements summarize work done by FWF Research Staff on the project during the report period; additional accomplishments by MRD and GADNR collaborators can be found elsewhere.

Introduction

The intent of our project is to provide a comprehensive and proactive assessment of *Enneacanthus chaetodon* distribution, relative abundance, and genetic health of SC and GA populations. We will achieve our goal through the development and application of a new eDNA tool combined with traditional surveys and population genetics. The specific project objectives and their quantifiable metrics for Year 1 include:

1) develop and test an eDNA detection tool for *E. chaetodon*: number of primers tested, number of species amplifying with primers, completion of laboratory experiments, eDNA sampling of four known *E. chaetodon* locations, analysis of test results to determine optimal eDNA sampling protocols.

2) use the eDNA tool to conduct field surveys in appropriate *E. chaetodon* habitats throughout SC and GA.

Materials and Methods

Freshwater Fisheries staff time was devoted to Objective 2, field surveys of appropriate E. chaetodon habitats in SC. Specifically, our task in Year One was to select 30 collection localities in SC and develop a protocol for habitat measurements to provide data for future occupancy modeling efforts. Our proposal stated field collection of water samples for eDNA extraction would begin in Year One, but due to the historic flooding events during October 2015 in SC, no eDNA sampling has occurred in SC yet.

Results and Discussion

We generated our preliminary survey site list; four sites representing historic collection locations are included as well as an additional 60 potential sites that were randomly selected from our state GIS database based on appropriate E. chaetodon habitat suitability (Figure 1). A total of 26 sites from the 60 random sites will be included in the eDNA survey. The current list includes collection locations from all five of the major river basins in the state – including the ACE, Catawba, Pee Dee, Santee, and Savannah basins.

Our field protocol was developed in conjunction with MRD and GADNR staff to ensure standardized procedures. During the eDNA survey, water quality characteristics are documented at the site level and comprise water temperature, pH, dissolved oxygen, conductivity, turbidity, and water color. A total of 20 replicate 2 L surface water samples are collected across all of the sample sites. Decimal degree GPS coordinates, time of sampling, substrate type, depth, current velocity, debris type, photos, and vegetation type are documented within a 1 meter grid at all 20 individual water sampling locations. Water body widths are measured at every 5th replicate water sample taken at each site. All water samples are taken prior to disturbing the area and caution is taken not to cross contaminate samples within a site and samples between sites. All materials which are to contact water at a site prior to water samples being taken (waders, boots, etc.) are decontaminated with 10% bleach and rinsed with DI water between each site.

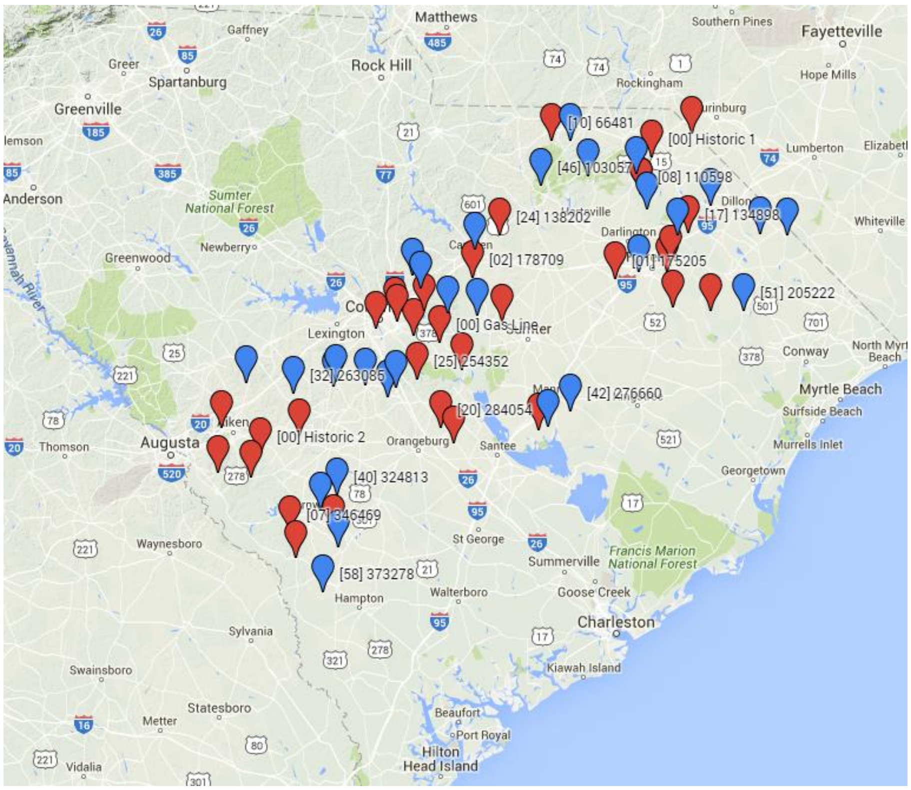

Figure 1. Map showing the initial eDNA sampling locations for SC. The red markers indicate the 4 historic locations and first 26 randomly selected sites; the blue markers represent the remaining randomly selected sites that will be used if needed for site replacement.

Recommendations

This report covers Year One of a three year grant; we recommend the project continue as outlined in the proposal.

Prepared By: Mark Scott, Kevin Kubach, Drew Gelder, Kenson Kanczuzewski

Title: Wildlife Biologists

Job Title: Fish Community Response to Dam Removal in Twelvemile Creek, Pickens County, South Carolina

Period Covered October 1, 2014 – September 30, 2015

Summary

This progress report summarizes work done during the report period. Complete samples according to standardized methods described below were obtained in Fall 2014 and Fall 2015. The study is ongoing through 2016.

Introduction

Dams alter riverine environments by converting lotic habitats to lentic ones, thereby altering physical habitat, flow-regimes, temperature-regimes, sediment transport, dendritic connectivity, and nutrient cycling (Bednarek 2001). As a consequence, dams change the composition, structure, and function of native fish communities (Martinez et al. 1994, Taylor et al. 2001, Santucci et al. 2005). Few evaluations of the ecological effects of dam removal have been conducted in North America due to the lack of opportunity, particularly in the Southeast. A rare opportunity has presented itself with the removal of two mainstem dams on Twelvemile Creek, Pickens County, South Carolina (Figure 1).

Twelvemile Creek was extensively polluted with PCBs originating from a capacitor manufacturing plant from 1955-1975; the waste site and its receiving waters were listed with the EPA Superfund Program in 1990. Under CERCLA statute (Superfund law), a natural resources board of trustees is authorized to act as trustees of natural resources on behalf of the public, and within that role they may assess and recover damages for injuries and losses to natural resources caused by a hazardous waste site. As part of the settlement for damages caused by PCB

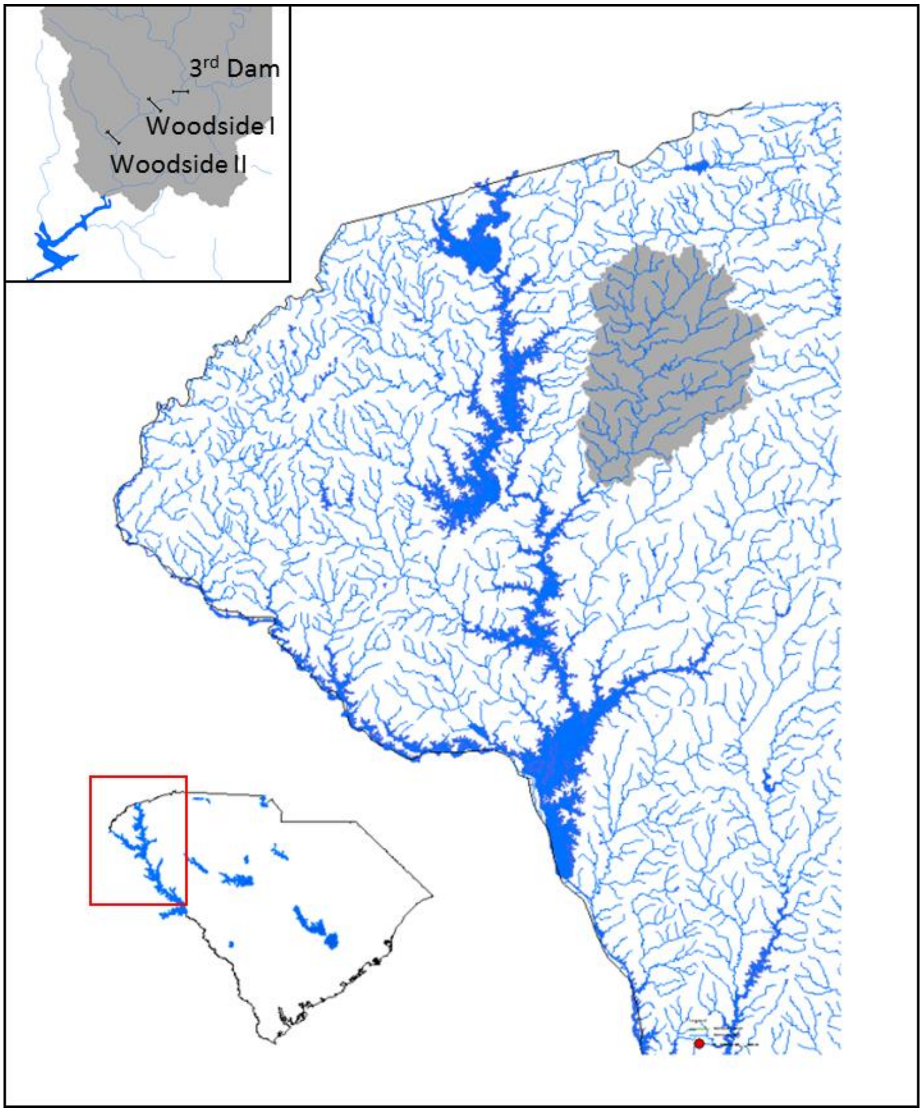

Figure 1. Twelvemile Creek drainage shaded in gray. Inset shows location of two former mainstem dams (Woodside I and Woodside II), and the remaining third dam (Easley-Central Dam).

contamination, a natural resources board of trustees facilitated the removal of two mainstem dams on Twelvemile Creek in order to 1) remove any remaining contaminated sediments that have accumulated behind the dams, and 2) to promote sediment transport to further ‘cap’ contaminated sediments downstream and in Lake Hartwell. Dam removal began in August 2009 with the initial dredging behind the upper dam (Woodside I); this dam was completely removed by April 2011. Dredging and removal preparations on the lower dam (Woodside II) began in April 2011, and removal was completed in September 2011.

The objective of this investigation was to document changes in the fish communities of Twelvemile Creek before and after the removal of the two dams (Woodside I and Woodside II). We have been monitoring fixed stations since 2006, and are scheduled to complete the study in 2016.

Materials and Methods

Six sampling stations were established for collecting biological and habitat data (Figure 1). The sampling stations are distributed as follows: 1) an alluvial stream section downstream of Woodside II Dam (Twelvemile Lower), 2) a bedrock-constrained free-flowing stream section downstream of Woodside II Dam (Woodside II Below), 3) an impounded area above Woodside II Dam (Woodside II Above), 4) a bedrock-constrained free-flowing stream section downstream of Woodside I Dam (Woodside I Below), 5) an impounded area above Woodside I Dam (Woodside I Above), and 6) an upstream reference station located upstream of both Woodside I and II, as well as upstream of a third dam (Robinson Bridge; Figure 1).

In addition, two sites on a nearby stream that has not been modified by dams, Three & Twenty Creek, were also established as additional reference. Fishes were collected at 20 wadeable stream segments of approximately 15m² within 300m segments at each site with a standardized effort using electrofishing gear and seines. All fishes encountered were collected, field identified to species level, recorded, and released. Habitat measurements of depth, velocity, and substrate were recorded at each of the 20 replicates; average widths were recorded at each site.

Results and Discussion

Total numbers of fish collected in Fall 2014 are shown in Table 1. Fall 2015 collections are shown in Table 2.

Recommendations

We will continue standardized sampling according to schedule at Twelvemile Creek and Three and Twenty Creek to provide a multi-year record of post dam-removal ecological conditions.

Literature Cited

Bednarek, A.T. 2001. Undamming rivers: a review of the ecological impacts of dam removal. Environmental Management 27:803-814.

Martinez, P.J., T.E. Chart, M.A. Trammel, J.G. Wullschleger, and E.P. Bergerson. 1994. Fish species composition before and after construction of a mainstem reservoir on the White River, Colorado. Environmental Biology of Fishes 40:227-239.

Taylor, C.A., J.H. Knouft, and T.M. Hilland. 2001. Consequences of stream impoundment of fish communities in a small North American drainage. Regulated Rivers: Research and Management 17:687-698.

Santucci, V.J., S.R. Gephard, and S.M. Pescitelli. 2005. Effects of multiple low-head dams on fish, macroinvertebrates, habitat, and water quality in the Fox River, Illinois. North American Journal of Fisheries Management 25:975-992.

Table 1. Summary of fish species and numbers collected in Twelvemile and Three and Twenty Creeks in Fall 2014.

Species\Site	Robinson Bridge	Woodside I Above	Woodside I Below	Woodside II Above	Woodside II Below	Twelvemile Lower	3&20 LaFrance	3&20 Burns Bridge	Total
Blackbanded Darter	13	11	7	3	11	3	9	5	62
Bluehead Chub	1	40	40	26	11	2	18	7	145
Bluegill	0	0	1	4	3	29	7	5	49
Channel Catfish	0	0	0	0	0	1	0	0	1
Eastern Silvery Minnow	0	0	0	2	0	31	0	0	33
Green Sunfish	0	0	0	0	1	0	0	2	3
Margined Madtom	0	3	3	7	1	0	2	4	20
Northern Hog Sucker	7	49	16	8	2	8	1	3	94
Notchlip Redhorse	0	0	0	0	0	5	0	0	5
Redbreast Sunfish	0	0	3	0	0	2	4	1	10
Redeye Bass	0	1	0	0	0	0	0	0	1
Redeye Bass x Spotted Bass	0	0	1	2	0	0	0	0	3
Redear Sunfish	0	0	0	0	0	2	0	0	2
Rosyface Chub	6	6	5	2	0	0	0	0	19
Snail Bullhead	1	13	10	2	0	0	0	0	26
Spotted Bass	0	1	0	0	1	0	0	0	2
Spottail Shiner	0	1	33	60	3	144	30	6	277
Turquoise Darter	0	20	21	12	18	0	0	0	71
Whitefin Shiner	7	3	12	15	10	175	2	5	229
Yellowfin Shiner	1	22	41	30	6	6	32	4	142
Total Individuals	36	170	193	173	67	408	105	42	1194
Taxa Richness	7	12	13	13	11	12	9	10	21

Table 2. Summary of fish species and numbers collected in Twelvemile and Three and Twenty Creeks in Fall 2015.

Species\Site	Robinson Bridge	Woodside I Above	Woodside I Below	Woodside II Above	Woodside II Below	Twelvemile Lower	3&20 LaFrance	3&20 Burns Bridge	Total
Blackbanded Darter	9	15	14	5	14	6	8	6	77
Bluehead Chub	2	21	24	13	13	7	14	23	117
Bluegill	1	0	1	12	19	20	12	13	78
Channel Catfish	0	0	0	0	0	11	0	0	11
Eastern Silvery Minnow	0	2	2	65	1	21	0	1	92
Flat Bullhead	0	0	1	0	0	0	1	0	2
Flathead Catfish	0	0	0	0	0	1	0	0	1
Green Sunfish	2	0	0	1	1	0	0	9	13
Largemouth Bass	0	0	0	0	2	1	0	4	7
Margined Madtom	0	3	1	5	0	0	5	2	16
Northern Hog Sucker	9	57	30	17	10	22	8	17	170
Notchlip Redhorse	0	0	0	0	0	4	0	0	4
Redbreast Sunfish	3	0	1	0	1	2	4	3	14
Redeye Bass	0	0	3	2	0	0	0	2	7
Redeye Bass x Spotted Bass	0	0	1	0	0	0	0	1	2
Roseyface Chub	0	4	3	0	0	0	1	0	8
Snail Bullhead	1	17	24	5	1	0	0	2	50
Spotted Bass	0	0	0	0	0	3	0	0	3
Speckled Madtom	0	0	0	0	0	0	4	0	4
Striped Jumprock	0	0	0	0	0	1	0	20	21
Spottail Shiner	0	7	15	110	58	80	15	46	331
Turquoise Darter	0	17	22	0	7	0	0	0	46
Warmouth	0	0	0	0	0	0	0	1	1
Whitefin Shiner	14	7	6	13	40	61	0	10	151
Yellowfin Shiner	0	30	35	3	5	3	12	5	93
Yellow Perch	0	0	0	0	0	0	1	0	1
Total Individuals	41	180	183	251	172	243	85	165	1320
Taxa Richness	8	11	16	12	13	15	12	17	28

Prepared By: Andrew Gelder, Mark Scott   Title: Wildlife Biologists

Job Title: Assessing introgressive hybridization within and habitat requirements of native South Carolina redeye bass

Period Covered July 1, 2014 – June 30, 2015

Summary

Work has continued on the study of redeye bass *Micropterus coosae* in South Carolina, the impacts of hybridization among black bass species on redeye populations, and associated outreach efforts. We presented past study results and an overview of the National Fish and Wildlife Federation's Native Black Bass Initiative to a Tri-State meeting of North Carolina, South Carolina and Georgia biologists. An internal meeting was also held to discuss the current status of our work, and future priorities. This will be revisited once work to establish genetic and habitat baselines in select redeye bass streams is completed in FY16. We continued to coordinate with Region 1 and with outside partners in the collection of data for the establishment of genetic and habitat baselines. We collected 37 black bass from three sites on Big Generostee Creek via angling and back pack electrofishing. Staff also assisted Region 1 significantly in the collection of black bass from multiple sites on Twelvemile Creek, Little River, and Eastatoee River. Complete genetic results are pending, but preliminary results indicate pure populations of redeye bass persist in the Chauga River, Chatooga River and potentially the upper reaches of Little River, despite the presence of Alabama bass and their hybrids in the lower most sampling sites on some streams. Outreach efforts included presenting a visiting lecture on this work to students in the upstate. This was a collaborative effort with the local B.A.S.S. Federation Conservation Director.

Introduction

The redeye bass (Hubbs and Bailey 1940) is one of two black bass native to South Carolina, and has been identified by South Carolina's Comprehensive Wildlife Conservation Strategy as a Species of Highest Priority due its restricted range and threats from introduced species (Kohlsaat et al. 2005). In South Carolina the species' native range is restricted to the Savannah Basin above the Fall Line. Redeye bass occupy habitats in cool-water streams (Rhode et al. 2009) and in addition have historically thrived within four of the Savannah River basin's man-made reservoirs; Jocassee, Keowee, Hartwell and Russell (Koppelman and Garret 2002).

Recent studies examined the relationship among populations of redeye bass across the range of the species. Mobile Bay drainage redeye bass are morphologically distinct from Atlantic Slope populations, with the common name Bartram's bass assigned to the latter (Freeman, unpublished data). DNA sequence data supports this distinction, and further suggests species-level divergence between Savannah River redeye bass and those of other Atlantic Slope drainages (Oswald 2007; Freeman et al. 2015). Savannah River redeye bass represent a highly divergent and distinct evolutionary lineage, and is one of three focus species in the National Fish and Wildlife Foundation's Native Black Bass Initiative (Birdsong et al. 2010).

Introductions of the non-native Alabama bass *Micropterus henshalli* into Lakes Keowee and Russell have put Savannah River redeye bass at risk due to introgessive hybridization (Barwick et al. 2006). Genetic surveys in 2004 and 2010 showed that Alabama bass have expanded within the drainage, as have their hybrids with redeye bass (Leitner et al. 2015). Both are present in all four lakes surveyed, and in 2010 together they comprised from 48% to 68% of black bass collected from each reservoir (Bangs et al. 2015). The survey of tributaries of the drainage indicated in 2004 that those redeye populations were for the most part still unimpacted by hybridization, but in 2010 an increase in Alabama bass alleles was noted for several tribs (Leitner et al. 2015). Alabama bass are known to take advantage of stream habitats, and the continued spread of their alleles throughout the drainage is a possibility.

Current objectives of this study include completion of development of new fast genetic assays, a longitudinal genetic assessment of redeye bass tributary populations using those assays, and collection and analysis of associated habitat data. Work in the last year has focused on those objectives.

Materials and Methods

Work has continued on development of fast genetic assays. Last year we reported on our use of Molecular Beacon software to identify suitable probe sequences for three loci, Actin, Calmodulin and ITS. Hydrolysis probes were designed and synthesized for Actin and Calmodulin and tested for Alabama bass, redeye bass and hybrids. For these loci assay conditions have been optimized and are now in routine use. Implementation of similar probes for the ITS locus has been problematic. To circumvent this, we have synthesized 300 base pair single-stranded ITS templates for use in probe optimization. We are pursuing a two-step ITS probe assay that first amplifies the ITS locus from the whole genomic DNA template (instead of the standard approach that amplifies the ITS locus and assays for species-specific polymorphism simultaneously), followed by a separate probe assay on this amplified product. This work is underway.

Fish were collected from priority streams via angling and backpack electrofishing. All black bass collected were weighed (g), measured (tl, mm), photographed, and finclipped. Finclips were stored in 95% ethyl alcohol pending genetic analysis using a combination of direct sequencing (mtDNA; ND2 locus) and the previously described probes (nDNA; Actin and Calmodulin loci).

Habitat assessment data was collected using the ‘zig zag’ method as adapted from Bevenger and King (1995) and described in the South Carolina Stream Assessment Standard Operating Procedures (M. Scott et al. 2009). At each fish collection site a representative 100 m long stream segment was identified. Flow, depth and substrate measurements were taken at 50 locations along the stream reach, moving in a zig-zag manner to proportionally represent multiple stream habitats (i.e. riffle, run, pool). At each of the 50 points selected, depth was measured (m) and water velocity (m/s) was taken using a flow meter and staff at 0.6 depth. Bottom substrate was blindly selected as the first object touched, categorized and recorded. Smaller portable rocks were measured by hand in mm. Large embedded rocks were estimated with a meter stick. Substrate categories and definitions are listed in Table 1.

Every 20 meters, wetted channel width was taken starting at zero meters using a range finder for a total of six width measurements within the 100-m reach. ‘Deep’ habitat was defined as ≥1.5 m. Length and width of deep sections were measured using a laser rangefinder. Using mean river widths (N=6) in conjunction with river habitat sampled (N=100m), total percentage of deep habitat was determined using the following equation:

$$\text{Total deep patch (m}^2\text{)/ Total area of transect (m}^2\text{)} *100.$$

Table 1. Substrate categories and definitions for habitat evaluations in Savannah Basin redeye bass tributaries.

Substrate Type / Category	Description	Size
Inorganics		
0.5 mm sand	Silt, fine sand	< 1 mm
Intermediate	Sand, rock, boulders or sheet rock	> 1 mm - < 999 mm
Hard Bottom	Boulder or bedrock	> 999 mm
Organics		
FPOM	Fine particulate organic matter	< 1 mm diameter
CPOM	Coarse particulate organic matter	1 – 50 mm diameter
FWD	Fine woody debris	3-10 cm diameter, > 50 cm length
LWD	Large woody debris	> 10 cm diameter, > 50 cm length

Results and Discussion

The ITS locus in the black basses that we have characterized by sequence analysis is 'GC' rich and, despite consultation with several design and synthesis companies, extremely difficult to optimize. This has complicated implementation of ITS probes that have been designed. GC rich templates have high melting temperatures. Small differences in melting temperatures that characterize species-specific mismatches (the basis of probe differentiation) are slight relative to the melting temperature that is characteristic of species pairs of ITS targets. Because of this, we have had a difficult time optimizing reaction conditions using our standard DNA templates. To date, the two step approach we have employed for ITS appears promising. Individuals that were previously characterized as pure and/or hybrid in origin have yielded probe-based genotypes that are entirely consistent. Once we have successfully characterized a suite of known individuals to gauge probe/assay specificity we will move forward with ITS assays of all unknown animals.

Fish collections were completed by Research and Region 1 staff on Twelvemile Creek, Eastatoee Creek, Little River and Generostee Creek, with 210 black bass collected. Black bass species collected included redeye bass, largemouth bass *Mircropterus salmoides*, Alabama bass and hybrids (Table 2).

Table 2. Number of black bass collected from Savannah basin streams in 2014 – 2015 by field id's; redeye bass (REB), largemouth bass (LMB), Alabama bass (ALB), redeye x Alabama bass hybrid (RAH).

			N Collected			
River	Site	Date	REB	ALB	RAH	LMB
Twelvemile Creek	Souliri Rd.	7/24/14	14	0	0	1
	Robinson Br.	8/7/14	19	0	2	5
	Bell Shoals Rd.	8/26/14	1	0	0	0
	Easley Central Dam	8/28/14	5	1	0	2
	Liberty Hwy	8/19/14	2	0	1	4
Eastatoee Ck.	Hemlock Hollow	10/8/14	1	0	0	17
	Eastatoee Baptist Ch	10/8/14	18	0	0	2
Little River	Burnt Tanyard Rd.	9/19/14	20	2	3	0
	Trombley	9/25/14	37	0	1	1
	Williams	9/11/14	14	0	0	0
Generostee Ck.	709 Bridge	10/20/14	13	0	0	0
		12/15/14	17	0	0	1
	Stream Team site at GC Hunt Club	12/15/14	3	0	0	0
	Bridge at GC Hunt Club	12/15/14	3	0	0	0

Genetic results for N=313 black bass are presented in Table 3. These include results for fish collected from priority streams since 2011. While field identifications do indicate the presence of non-native black bass in both Twelvemile Creek and Little River (Table 2), genetic results from the same streams demonstrate that hybrids are not always readily identifiable in the field. About 8 percent of fish collected from Twelvemile and Little River were field identified as hybrid or Alabama Bass, while genetically identified hybrids made up about 50 percent of those analyzed from the same collections. Complicating field identification of non-natives is that only a very small proportion of fish with non-native alleles present genetically as pure Alabama Bass (1 of 87 of the fish reported on here). The majority are hybrids of varying degrees. Fish with a proportion of alleles from one species or another can strongly resemble just one of its parental species. In the coming year genetic analysis will be completed across all loci and final proportions of Alabama Bass alleles will be calculated. Genetic results will be paired with field id's and field photographs into one data set which will be of great use to staff who will encounter these species in the field. It is apparent though that for an accurate determination of introgression in these populations, genetic analysis will remain crucial.

Introgression and upstream presence of hybrid individuals is variable among streams sampled. No non-natives were collected from Eastatoee Creek. Chauga and Chatooga Rivers yielded small numbers of hybrids, concentrated primarily in the most downstream sampling sites, while hybrids were collected from throughout the sampling areas on Little River and Twelvemile Creek. On Twelvemile Creek this included sites above Easley Central Dam, indicating that this in stream barrier has not protected redeye bass in the upper portions of the Twelvemile watershed from introgression with Alabama Bass. Further study in the Savannah Basin range of redeye bass is needed to define the areas or types of areas that may serve as refuge for this species.

Table 3. Preliminary numbers of Redeye Bass (REB), Alabama Bass (ALB) and hybrids (RAH) collected from Savannah Basin streams between 2011 and 2014, as identified by genetic analysis. For each stream, sites are listed in the order of their location along the stream gradient, with the most downstream site listed first. Data is presented for those fish for which we have confirmed results at a minimum of two nuclear loci.

		Species		
Stream	Site	REB	ALB	RAH
Twelve Mile	Lower / Maw Bridge Area	3	0	4
	Woodside II – Below	1	0	6
	Woodside II – Above	0	0	4
	Woodside I – Below	1	0	5
	Woodside I – Above	0	0	2
	Easley Central – Below	2	0	4
	Robinson Br.	6	0	13
	Souliri	1	0	13
	Liberty Hwy.	0	0	3
	Stewart Gin Rd.	1	0	5
	Belle Shoals	0	0	0
Chauga	Jenkins Bridge	6	0	3
	Chau-Ram Park	19	0	1
	Cobb Bridge	23	0	0
	Riley Moore	38	0	1
Chatooga	Opossum Creek	0	0	1
	Camp Creek	24	0	1
	Hwy 76	30	0	0
Little River	Burnt Tanyard Shoals	17	1	5
	Doc Trombley	24	0	13
	Williams	11	0	2
Eastatoee Creek	Hemlock Hollow	1	0	0
	Eastatoee Baptist Church	18	0	0

Stream habitat assessments were conducted for 16 sampling sites on Twelvemile Creek, Eastatoee River, Stevens Creek and Little River. Mean depth (m), mean velocity (m/s), median substrate (mm), mean river width (m), percentage of large woody debris (LWD) and percentage of deep habitat (> 1.5 m in depth) were calculated for all sites (Table 4). Stream sampling is ongoing, with fish and habitat data collections continuing on priority streams. Once completed habitat parameters, and watershed characteristics will be related back to the incidence of redeye bass, Alabama bass and hybrids in the sampled Savannah Basin populations.

Table 4. Calculated habitat variables by sample location, with mean and median values for each stream; Twelvemile Creek, Eastatoee Creek, Little River and Steven's Creek.

	mean depth	depth SD	mean velocity (m/s)	velocity SD	median substrate (mm)	mean width (m)	% Large Woody Debris	% deep habitat
Liberty Highway	0.42	0.16	0.25	0.13	1.00	19.42	20.00	0.00
Stewart Gin	0.48	0.18	0.37	0.23	2.00	12.00	4.00	0.00
Allgood Bridge	0.39	0.17	0.35	0.18	1.00	12.92	12.00	0.00
Belle Shoals	0.49	0.20	0.26	0.13	1.00	14.00	12.00	0.00
Easley Central	0.34	0.17	0.46	0.29	3.00	30.83	0.00	0.00
Robinson Bridge	0.42	0.12	0.34	0.19	0.50	17.00	22.00	0.00
Souliri	0.39	0.18	0.34	0.30	5.00	21.75	2.00	0.59
12 Mile	0.42	N/A	0.34	N/A	1.93	18.27	10.29	0.08
Hemlock Hollow	0.41	0.16	0.30	0.24	47.00	14.67	0.00	0.00
Eastatoee Church	0.39	0.23	0.37	0.25	25.00	10.75	4.00	5.21
Eastatoee	0.40	N/A	0.34	N/A	36.00	12.71	2.00	2.60
Burnt Tanyard	0.51	0.23	0.29	0.24	999.00	31.25	2.00	15.46
Doc Tromley	0.36	0.18	0.27	0.28	999.00	19.50	0.00	1.23
Williams	0.46	0.19	0.25	0.21	41.00	17.58	0.00	8.42
Little River	0.44	N/A	0.27	N/A	679.67	22.78	0.67	8.37
88 Highway	0.36	0.21	0.06	0.11	2.00	13.17	20.00	0.00
Highway 23	0.54	0.17	0.00	0.01	999.00	22.80	4.00	0.00
Highway 21	0.33	0.16	0.06	0.13	999.00	14.40	2.00	0.00
Blair Road	0.52	0.24	0.01	0.04	192.50	18.00	12.00	8.89
Parksville	0.25	0.16	0.06	0.09	44.00	16.08	10.00	9.95
Steven's Creek	0.40	N/A	0.04	N/A	447.30	16.89	9.60	3.77

Recommendations

Continue to work with Region 1 and outside partners to examine redeye bass stream populations in the Savannah Basin, to evaluate the extent of hybridization among and within stream populations, to identify refuge areas of pure redeye bass, and to prioritize stream populations and habitats for conservation. Prioritize research and outreach needs associated with Bartram's Bass. Convene a Bartram's Bass Working Group, to include but not be limited to staff from SCDNR and GADNR, to guide continued research and conservation of the species.

Literature Cited

Barwick, D. H., K. J. Oswald, J. M. Quattro, and R. D. Barwick. 2006. Redeye bass (Micropterus coosae) and Alabama spotted bass (M. punctulatus henshalli) hybridization in Keowee Reservoir. Southeastern Naturalist 5: 661-668.

Bangs, M. 2011. Decline of the Savannah River redeye bass (*Micropterus coosae*) due to introgressive hybridization with invasive Alabama spotted bass (*M. punctulatus henshalli*). Masters Thesis, University of South Carolina, Columbia, South Carolina

Bevenger, G.S., and R.M. King. 1995. A pebble count procedure for assessing watershed cumulative effects, USDA FS Research Paper RM-RP-319.

Birdsong, T., D. Krause, J. Leitner, J.M. Long, S. Robinson, and S. Sammons. 2010. A business plan for the conservation of native black bass species in the southeastern U.S. National Fish and Wildlife Foundation, Washington, D.C.

Freeman, Byron J., A. Taylor, K. Oswald, J. Wares, M. Freeman, J. Quattro, and J. Leitner. 2015. Shoal Basses: A Clade of Cryptic Identity, pages 449-466 *in* M. D. Tringali, J. M. Long, T. W. Birdsong, and M. S. Allen, editors. Black bass diversity: multidisciplinary science for conservation. American Fisheries Society, Symposium 82, Bethesda, Maryland.

Hubbs, Carl L. and Reeve M. Bailey. 1940. A revision of the black basses (*Micropterus* and *Huro*) with descriptions of four new forms. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 48.

Kohlsaat, Thomas, Lynn Quattro and Jennifer Rinehart. 2005. South Carolina Comprehensive Wildlife Conservation Strategy. South Carolina Department of Natural Resources, Columbia, South Carolina

Koppleman, Jeffrey B. and Gary P. Garrett. 2002. Distribution, biology, and conservation of the rare black bass species. Pages 333-341 in D. P. Philipp and M. S. Ridgeway, editors. Black bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Leitner, Jean K., K. J. Oswald, M. Bangs, D. Rankin, and J. M. Quattro. 2015 Hybridization between native Bartram's Bass and Two Introduced Species in Savannah Drainage Streams *in* M. D. Tringali, J. M. Long, T. W. Birdsong, and M. S. Allen, editors. Black bass diversity: multidisciplinary science for conservation. American Fisheries Society, Symposium 82, Bethesda, Maryland.

Liu, J., S. Huang, M. Sun, S. Liu, Y. Liu, W. Wang, X. Zhang, H. Wang and W. Hua. 2012. An improved allele-specific PCR primer design method for SNP marker analysis and its application. Plant Methods 8:34.

Oswald, Kenneth J. 2007. Phylogeography and contemporary history of redeye bass (*Micropterus coosae*). Dissertation, Department of Biological Sciences, University of South Carolina.

Rhode, Fred C., Rudolf G. Arndt, Jeffrey W. Foltz, and Joseph M. Quattro. 2009. Freshwater Fishes of South Carolina. University of South Carolina Press. Columbia, South Carolina.

South Carolina Department of Natural Resources. 2009. The South Carolina Stream Assessment Standard Operating Procedures. Version 2009. Freshwater Fisheries Section.

Prepared By: Jean Leitner and Kenson Kanczuzewski

Title: Fisheries Biologist

Job Title: Redbreast Stocking Evaluation – Edisto River

Period Covered July 1, 2014 – June 30, 2015

Summary

An evaluation of the stocking of redbreast sunfish *Lepomis auritus* on the Edisto River was initiated in FY 2011 and continued through FY 2015. Mark evaluations were completed in FY 2014 for known marked fish of the 2013 year class, and this was reported on last year. In FY 2015 redbreast sunfish were collected from the Edisto River and otoliths were removed from all fish. Age estimations were made on whole otoliths to identify fish from the 2013 year class. These otoliths were mounted and sectioned for oxytetracycline (OTC) mark determination. First reads on these otoliths are complete and second reads are in progress. Also in FY 2015 approximately 290,000 redbreast were produced (2014 year class), immersion-marked in OTC, and stocked in a prescribed zone of the Edisto River main stem. Mark evaluations on N=15 known marked fish from this year class were completed and OTC marks were confirmed on all fish examined. These included representatives from 3 separate mark events. Plans are to assess the contribution of hatchery stocked fish from the 2014 year class with collections of adults from the wild. This will represent the third year class assessed for this study.

Introduction

Redbreast sunfish is a much sought after sport fish on the Edisto River. This is evidenced in collections made in 2004 that spanned a very high water event. Those collections suggest that once hydrologic conditions normalized, allowing for greater river access and angling, larger fish were quickly exploited and removed (Bulak 2005). The annual stocking of the Edisto River with redbreast sunfish began in 1995. This was in response to public concerns that introduced flathead catfish

Pylodictis olivaris were negatively impacting the popular fishery. Records show approximately 13.7 million redbreast stocked in the river since 1995, with annual stocking ranging from 0.45-2.2 million.

The supplemental stocking of redbreast sunfish in Edisto River has never been evaluated. Collections of microtagged redbreast sunfish that were stocked in Little Pee Dee River from 1990 – 1992 suggested minimal contribution, though further sampling was recommended before drawing conclusions from the available data (Crochet and Sample 1993). Genetic survey of redbreast sunfish populations across five South Carolina drainages indicated Edisto river redbreast were markedly less diverse than redbreast populations from other drainages (Leitner 2006). This could be a result of lost diversity in the former hatchery population and its impact on the receiving population in the river, or could be an indication of bottleneck events occurring in the wild. To best manage this resource, we need a basic understanding of whether supplemental stocking is contributing to the redbreast sunfish population and fishery of the Edisto River. In the last year approximately 290,000 redbreast were produced (2014 year class), immersion-marked in oxytetracycline (OTC), and stocked in a prescribed zone of the Edisto River main stem. A mark evaluation of known marked fish from this year class was conducted and mark evaluations were begun on 2013 year class fish that were collected from the wild.

Materials and Methods

Fish were collected by boat electrofishing from the Edisto River in the Fall of 2014, and provided to this lab for ageing and OTC mark evaluation. This was to target the 2013 year class at age 1. Otoliths were extracted from all fish and aged whole. Otoliths from fish estimated to be age 1 were processed according to standard procedures for OTC mark evaluation.

Known marked redbreast sunfish fingerlings from three mark events in 2014, and known unmarked fish from the same year class were grown out for approximately 6 months, and then provided to this lab for mark evaluation. Otoliths from these fish were processed according to standard procedures for OTC mark evaluation.

Results and Discussion

Fish from the 2013 year class represent the second year class we have collected for the assessment of hatchery contribution. The first was from 2010, and at age 1+ hatchery fish comprised 9% of the total redbreast collected. Difficulties in marking and grow out precluded our assessment of fish stocked in 2011 and 2012.

Of fish aged from 2014 collections n=210 were estimated to be age 1 and from the 2013 year class. Initial OTC mark evaluation reads have been completed on these fish, and second reads are in process. Once completed contribution of stocked fish to the 2013 year class will be calculated.

OTC marks were identified for all known marked fish evaluated (N=15) from the 2014 year class. All marks were bright and readily visible. We have not received collections of this year class from the wild. Region 3 staff planned for these collections in Fall 2015, but they have not taken place due to extremely high water levels in the Edisto River.

Recommendations

Continue study. Complete assessments of the 2013 year class. Collect and assess the 2014 year class from the wild when possible which would represent a third year class evaluation and completion of the study. Whenever marking fish with OTC, ensure an extended grow out is allowed for a sufficient sample of fish from each mark event, and of known unmarked fish from the same year class.

Literature Cited

Bulak, James S. 2005. Recruitment and growth of Edisto River redbreast sunfish. Study Completion Report. South Carolina Department of Natural Resources.

Crochet, Daniel W. and Christopher W. Sample. 1993 Fisheries Investigations in Lakes and Streams – District VII. Study Completion Report F-31-4. South Carolina Department of Natural Resources.

Leitner, Jean. 2006. Zoogeography of Centrarchidae of the Atlantic Slope. Study Completion Report. South Carolina Department of Natural Resources.

Leitner, Jean. 2011 Redbreast Stocking Evaluation – Edisto River. Study Progress Report. South Carolina Department of Natural Resources.

Prepared By: Jean Leitner Title: Fisheries Biologist

Job Title: Crappie Data Compilation and Evaluation

Period Covered July 1, 2014 – June 30, 2015

Summary

A compilation of trap net data was completed for Lakes Greenwood, Murray, Wylie and Thurmond and von Bertalanffy growth curves were produced for each population. Growth is variable with crappie from most populations recruiting to the fishery at around age 2. In an effort to collect older fish, we contacted local fishing clubs and collected 20 crappie in conjunction with a winter tournament on Lake Murray. Forty five percent of Lake Murray tournament caught fish were age 4 or greater with the oldest fish age 11, compared to 25% of crappie collected incidental to spring electrofishing for largemouth bass and 2 % of fish collected trap netting.

We evaluated spring electrofishing to target crappie on Lake Wateree. Electrofishing was conducted from March 11 – May 5, 2015. Ninety seven black crappie *Pomoxis nigromaculatus* were aged ranging in size from 127 – 355 mm TL with a mean TL of 300 mm. Fish ranged in age from 1 – 12, and 82 percent of fish collected were age 4 or older. Spring electrofishing appears to be an effective option for collecting adult crappie, but an alternative method of collection is suggested for younger fish. Additionally, spring electrofishing targets fish that are on the spawning grounds at the time of collection. The age structure of fish on the spawning grounds at any given time may not be reflective of all adult fish. We found 2 and 3 year old fish to be largely absent from collections in March, though they were collected routinely in April and May.

Updates on this work were provided to the Freshwater Fisheries Section Coordinators at January and June meetings. We also completed a literature review on supplemental stocking of black crappie and provided that information to the section.

Introduction

Crappie are an economically and recreationally important sportfish in South Carolina. The species group is ranked first in number of days and second in total number of anglers based on South Carolina respondents to the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USFWS 2006). In addition to individual recreational anglers, a number of fishing clubs both local and national maintain active tournament schedules with frequent events on South Carolina lakes.

There are two species of crappie and both are present in South Carolina. Black Crappie *Pomoxis nigromaculatus* is native to all South Carolina drainages and is widely distributed throughout the state. White Crappie *P. annularis* is introduced. Though established in some areas of the Piedmont and Inner Coastal Plain regions, this species remains generally rare (Rohde et al. 2009). While White Crappie are collected and recorded in South Carolina in the routine survey of crappie, their numbers are very small. All of the data reported on here is for individuals identified as Black Crappie.

Crappie are often reported to be a difficult fish to manage (Maceina and Stimpert 1998). Growth and recruitment can vary widely both among populations, and among year classes within populations (Allen and Miranda 1998, 2001). Responses to management actions can vary widely as well (Wright et al. 2015). In an effort to better understand the dynamics of crappie populations in South Carolina, we have worked to compile statewide data produced largely through our routine effort to track populations via fall trap netting. We have evaluated trap net data from the last ten years, and have explored additional sampling strategies. Here we report on growth differences among populations of interest, the need to collect fish from older size classes, and the potential that using more than one sampling strategy may be effective and necessary to fully evaluate crappie populations in South Carolina.

Materials and Methods

Regional personnel provided data collected in the routine sampling of crappie, both current and that from approximately the last 10 years. Data received included that collected via fall trap netting as well as from crappie collected incidental to spring electrofishing for largemouth bass. Size, age and sex data were compiled from all regions into a standard format for analysis and archiving. Von Bertalanffy growth curves were generated for Lakes Greenwood, Murray, Wylie and Thurmond.

In an effort to collect older fish we contacted local fishing clubs and were welcomed to attend the weigh in for a winter tournament on Lake Murray. Staff was present at the weigh in to take measurements and collect otoliths from catches with individual angler's permission.

To evaluate spring electrofishing to target crappie on Lake Wateree we sampled shoreline areas using a boat mounted electrofisher. Total length was recorded for all crappie collected. We retained the first 12 fish from each 10 mm size class for ageing, and all additional fish collected in that size class were measured and released. Otoliths were pulled from retained fish and aged whole by an experienced reader. When estimating age from the whole otolith was problematic otoliths were cracked by hand and polished to produce a more clear view of the space between annuli and between the last annulus and the otolith edge.

Results and Discussion

A compilation of trap net data was completed for Lakes Greenwood, Murray, Wylie and Thurmond. This dataset includes 6,577 fish collected from 2005 to 2014. Growth evaluations indicate crappie from most populations recruit to the fishery (203 mm tl) at around age 2, though Lake Wylie exhibited faster early growth recruiting at around age 1.5 (Figure 1). Trap nets primarily collect fish 0 – 3 years old. Because of the relative scarcity of fish age 4 or older in trap net catches, reliance on this data alone limits our ability to best evaluate and compare growth and longevity among populations.

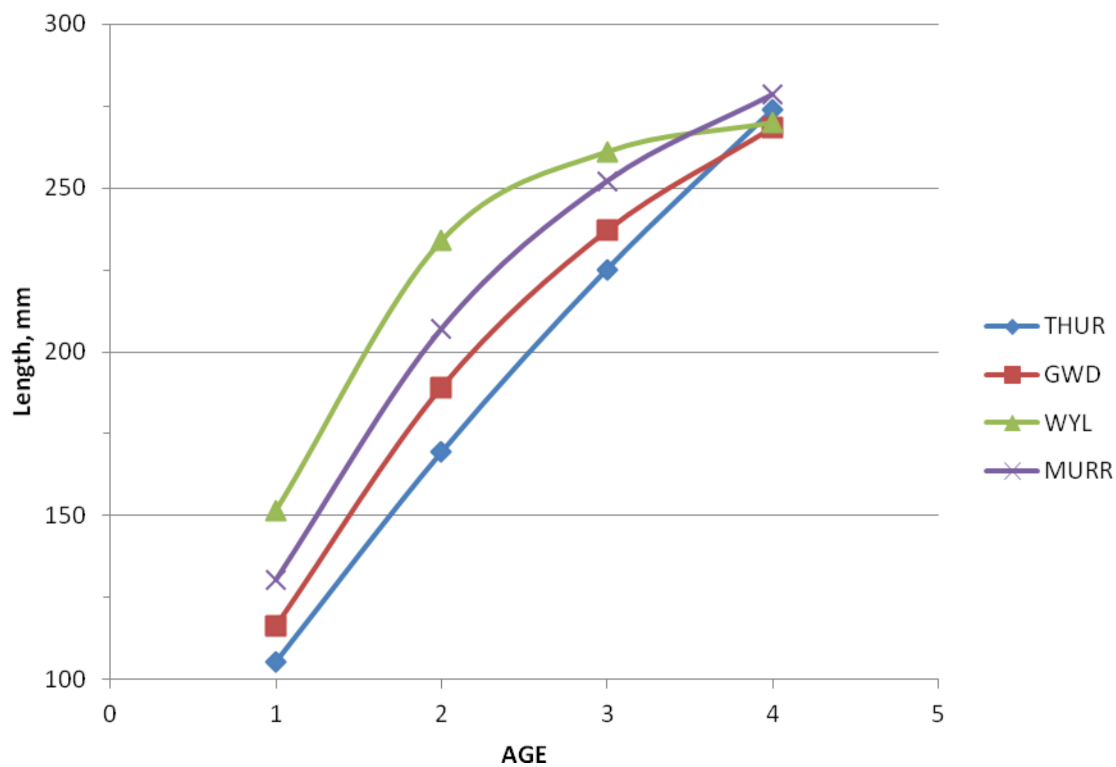

Figure 1. Von Bertalanffy back crappie predicted length at age for South Carolina reservoir populations; Lakes Thurmond (THUR), Greenwood (GWD), Wylie (WYL) and Murray (MUR).

Twenty fish were donated by Lake Murray tournament anglers for data collection (mean TL 317mm; range 248-375mm). Forty five percent of these fish were age 4 or greater with the oldest fish age 11, compared to 25% of crappie collected from Lake Murray incidental to spring electrofishing for largemouth bass (total n=131; mean TL 266 mm; range 128 – 358 mm), and 2 % of fish collected trapnetting (total n=3934; mean TL 152 mm; range 9 – 419). Size class frequency varied among sampling methods (Figure 2). This look at collections by multiple sampling methods from the same population show that data collection by more than one method can be important to provide information on the full range of size and age classes present.

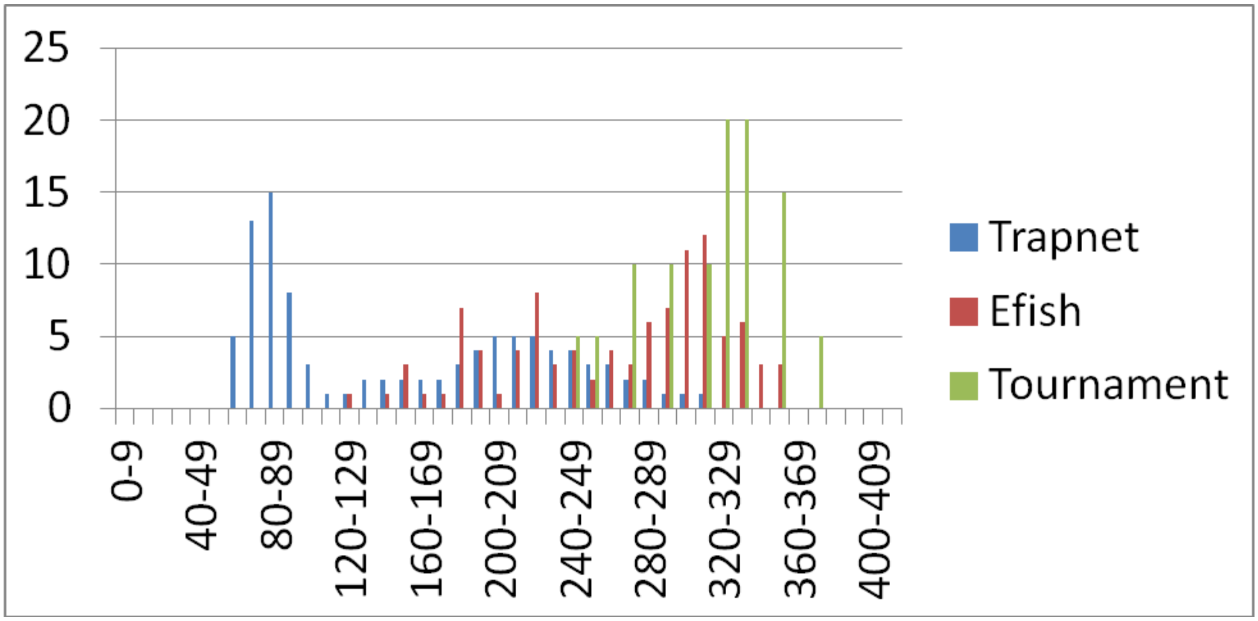

Figure 2. Percent frequency by 10 mm total length group, of black crappie collected from Lake Murray using three different sampling strategies; Fall trapnetting (N=3386), Spring electrofishing catches incidental to largemouth bass sampling standard protocol (Efish, N=131), and Winter tournament angling (N=20).

We were very well received by members of the South Carolina Crappie Association and most participating anglers were very interested in learning of our efforts regarding crappie. All but one angler who weighed in fish was willing to have staff take data from those fish, and all of those anglers elected to provide their fish whole to staff for processing later at the lab. We provided the club president with a report of our findings for him to share with his membership. There are a number of clubs both local and national with active tournament schedules that include South Carolina lakes. The collection of data in conjunction with these events can provide both valuable data for our crappie management efforts and an opportunity for outreach and engagement of the crappie angling public.

Electrofishing was conducted on Lake Wateree from March 11 – May 5, 2015. Efforts were focused in Wateree Creek and Taylors Creek where 315 crappie were collected and total length recorded (Table 1). Ninetyseven black crappie were aged ranging in size from 127 – 355 mm tl (mean TL = 300 mm). Fish ranged in age from 1 – 12, and 82 percent of fish collected were age 5 or older (Table 2). Collections were dominated by fish from the 2010 year class (age-5). This is the same year class that currently dominates the population in Lake Wylie. An evaluation of pre and post spawning hydrologic conditions in the Catawba-Wateree Basin in 2010 may be informative.

Spring electrofishing appears to be an effective option for collecting spawning age crappie, but an alternative method of collection is suggested for younger fish. Additionally, spring electrofishing targets fish that are on the spawning grounds at the time of collection. The age and size structures of fish on the spawning grounds at any given time may not be reflective of all spawning age fish (Tables 1 and 2). We found 2 and 3 year old fish, and those less than 270 mm tl, to be largely absent from collections in March, though they were collected routinely in April and May.

Table 1. Black Crappie collected from Lake Wateree in 2015 by spring electrofishing. Number of fish collected are listed by date (month/day) and 10 mm tl group.

	N Collected by Date					
10 mm tl group	3/11	3/20	3/30	4/10	4/20	5/4-5/5
200-209						
210-219						
220-229				1	1	
230-239					1	1
240-249				1	2	1
250-259				3	2	
260-269					1	6
270-279	1			3	6	6
280-289	1	1	3	1	9	16
290-299	2		1	12	9	28
300-309	3	3	5	8	11	11
310-319	7	7	7	6	8	14
320-329	7	5	5	2	5	18
330-339	7	8	5	4	6	8
340-349	2	1	1	3	1	7
350-359			3			5
360-369	2					
370-379						
380-389		1				
390-399						
Total N by Date	32	26	30	44	62	121

Table 2. Black Crappie collected from Lake Wateree in 2015 by spring electrofishing. Number of fish collected are listed by date (month/day) and age.

	N Collected						Total N by Age
Age	3/11	3/20	3/30	4/10	4/20	5/4-5/5	
0							0
1						1	1
2	1			4	4	3	12
3				1	1	1	3
4							0
5	25	12	6	8	6	15	72
6			1		1	1	3
7							0
8			1			8	9
9					1	2	3
10							0
11							0
12			1				1

We will continue to work with fishery managers in developing a strategy for addressing crappie management in South Carolina. In the coming year this effort will include addition of any new data to the compiled database. It is suggested that methods to collect fish in older age classes be employed on populations of interest. An evaluation of age at maturity may also be of value. Where sufficient data exists, it will be used for more robust evaluations of growth, and to model fishery response to varying regulation changes.

Recommendations

Continue to update compiled database with new data as it is available. Employ sampling or collecting methods such as tournament sampling and electrofishing to augment data on populations of interest with older fish. Through routine trap netting efforts, collect information on age at maturity. Assess variability in age and growth among populations and year classes, and where sufficient data exists, model fishery responses to variation in regulations. Meet with regional staff to discuss findings.

Literature Cited

Allen, M. S. and L. E. Miranda. 1998. An age-structured model for erratic crappie fisheries. Ecological Modeling 107:289-303.

Allen, M. S. and L. E. Miranda. 2001. Quasi-cycles in crappie populations are forced by interactions among population characteristics and environment. Canadian Journal of Fisheries and Aquatic Sciences 58:594-601.

Maceina and Stimpert. 1998. Relations between reservoir hydrology and crappie recruitment in Alabama. North American Journal of Fisheries Management 18:104-113.

Rhode, Fred C., Rudolf G. Arndt, Jeffrey W. Foltz, and Joseph M. Quattro. 2009. Freshwater Fishes of South Carolina. University of South Carolina Press. Columbia, South Carolina.

U. S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2006. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Wright, Lynn D., John R. Jackson and Steve E. Lochmann. 2015. An evaluation of crappie supplemental stocking in Arkansas impoundments. Journal of the Southeastern Association of Fish and Wildlife Agencies 2:109-113.

Prepared By: Jean Leitner

Title: Fisheries Biologist

Job Title: Trophic resources for larval fish in Lake Marion

Period Covered July 1, 2014 – June 30, 2015

Summary

In 2014-2015 we continued to integrate results from main basin of upper Lake Marion to understand processes affecting abundances of zooplankton and phytoplankton, which support production of larval striped bass *Morone saxatilis* and other ichthyoplankton. We analyzed zooplankton composition and abundance on a longitudinal gradient in Lake Marion (April-October 2014 samples). We sampled zooplankton abundances in Lake Moultrie, beginning in June 2015. We evaluated diets of threadfin shad *Dorosoma petenense*, the dominant species, collected from pelagic habitats in Lakes Marion and Moultrie during late spring and summer. We refined a model for phytoplankton dynamics in the main basin of upper Lake Marion, incorporating improved estimates of phytoplankton imported from the river and the backwaters. Our completed analysis of the benthos of Lake Marion was accepted for publication in a peer-reviewed journal (Taylor, Bulak, and Morrison, in press).

Introduction

In 2008, the South Carolina Department of Natural Resources (SCDNR) re-convened the Santee-Cooper Comprehensive Study Group to provide an update and overview of current conditions in the system and to guide and promote development of a scientific basis for management decisions about aquatic resources within the Santee-Cooper basin. The work reported here is part of the final phase of studies directed toward developing process-based models of food resources and other factors that may affect recruitment of key resident and anadromous fish species in the Santee-Cooper system.

These species, as identified by the Study Group, include striped bass, American shad *Alosa sapidissima*, blueback herring *Alosa aestivalis*, threadfin shad, and white perch *Morone americana*. These key species have overlapping spawning seasons (April to June); they share nursery areas in upper Lake Marion; and, in their larval stages, they feed on zooplankton.

Our general objectives were to assess current conditions in the lake, quantify trophic structure, and to model and evaluate processes that may influence trophic interactions, with particular attention to the key fish species. A specific objective from the Study Group was to evaluate whether low zooplankton abundance, resulting in competition for food, may limit recruitment of key fish species. We focused sampling and modelling efforts on initially upper Lake Marion, because of its importance as a nursery. Subsequently, we extended efforts to lower Lake Marion and Lake Moultrie, where neither zooplankton nor benthos had previously been studied.

Materials and Methods

Zooplankton

Zooplankton were sampled at four stations in the main basin of Lake Marion (channel markers 44, 69, 79, and 150) on 7 dates in April-October 2014. Van Dorn bottle samples (2.2 L) were collected at 1-m depth intervals from 0-4 m. The samples for each station were combined, filtered onto an 80-micron mesh sieve, and preserved with sugar and formalin. To ensure an adequate sample of larger taxa, we also collected a vertical tow (0-4 m, depth permitting) at each station using a net with 25-cm aperture and 80-micron mesh.

Zooplankton were also sampled at four station in Lake Moultrie (channel markers 2 and 17 plus stations in the southeast and northwest quadrants of the lake) on five dates from June-October 2015. Protocols were similar to those used at Lake Marion.

Diets of threadfin shad

Threadfin shad were collected by gill nets or cast nets from pelagic habitats of Lakes Marion and Moultrie; most of the collections were made in conjunction with hydroacoustic surveys. Fish were placed on ice in the field, then identified, weighed, measured, and frozen in the laboratory. Contents of each dissected stomach, preserved in 70% ethanol, were washed onto a 53-micron mesh sieve, then stained with Eosin B. Subsamples were examined microscopically, and a random point count method, based on Wilson (2002), was used to evaluate relative abundance of detritus, phytoplankton, and zooplankton.

Phytoplankton dynamics model

The main features of the phytoplankton dynamics model, built to evaluate potential impacts of hydrologic processes and consumption by *Corbicula*, have been described in previous reports (Taylor, 2013 and 2014). Refinements include temperature- and density-dependencies for algal productivity. We used 2014 chlorophyll a measurements from Santee Cooper for the Congaree, Wateree, and Santee rivers as part of the basis for setting influent algal concentrations. (Santee Cooper routinely measures chlorophyll a only at lacustrine stations; they added riverine measurements to support our project.) We also estimated backwater contributions using 1987-2014 chlorophyll data from stations in Stump Hole Swamp and Elliott's Flats; data were obtained from the STORET water quality database maintained by the US EPA and from Santee Cooper.

Results and Discussion

Zooplankton

Zooplankton abundances were typically in low at all four stations in Lake Marion (Figure 1). Common rotifers included *Brachionus*, *Keratella*, *Polyarthra*, *Synchaeta*, and *Conochilus*. Common

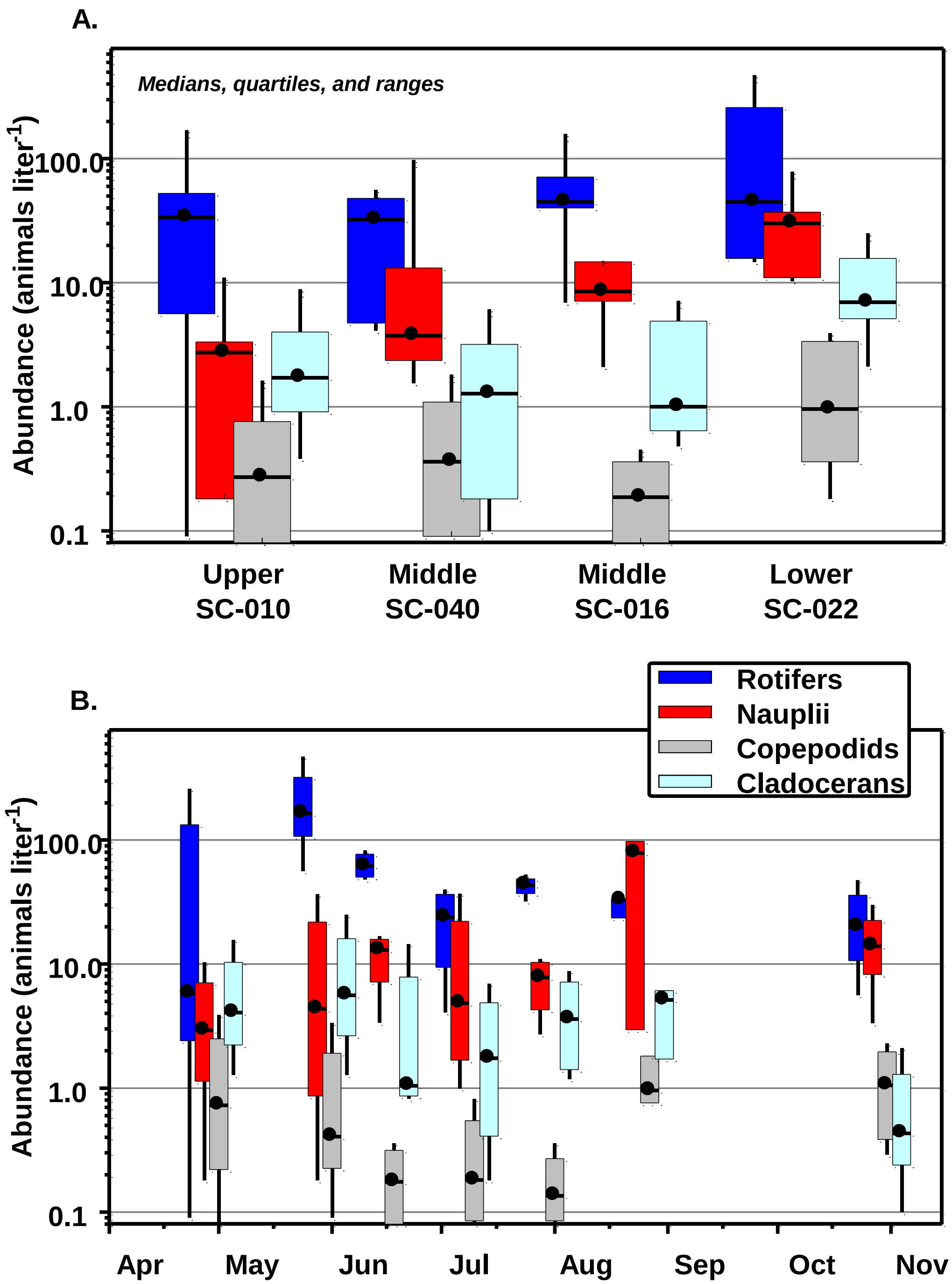

Figure 1. Abundances of zooplankton at four main basin stations in Lake Marion in April-October 2014. Stations were sampled on seven dates, except SC-016, which was sampled on six dates.

cladocerans included *Bosmina longirostris*, *Bosminopsis dietersi*, and other small-bodied taxa; *Daphnia lumholtzi*, a spiny, large-bodied invasive species, was abundant in a few samples. Copepods included the calanoids *Eurytemora affinis*, *Epischura fluviatilis*, *Osphranticum labronectum*, and *Diaptomus* spp., as well as cyclopoids.

We used analysis of variance on log-transformed abundances to explore the main effects of space and time. Across dates, abundances of copepod nauplii, copepod copepodids, and cladocerans, but not rotifers, differed among stations at $p<0.05$. For each of these taxonomic groups, abundances at the station in the lower region (SC-022) were greater than at two or all three of the stations in the middle and upper regions. Abundances of copepod nauplii and cladocerans also differed among dates. Across stations, nauplii were more abundant in August than in April or May, and cladocerans were more abundant in April and May than in October.

The lower zooplankton abundances in upper and middle regions of Lake Marion may reflect the greater impact of advective processes, particularly in the upper region, or consumption by fish (Taylor, 2014). The lower region appeared to offer similar or better resources for planktivorous fish than the middle and upper regions, although the upper region has been identified function as the main nursery, at least for larval striped bass (Bulak et al., 1997).

Diets of pelagic threadfin shad

Threadfin shad is one of the dominant pelagic fish in this system. Its diet is highly variable, and it often feeds mainly as a detritivore (e.g., Hendricks and Noble, 1997). In Lake Jordan, North Carolina, Jackson et al. (1990) found that both threadfin and gizzard shad were detritivores, except during "a brief period early in the growing season coincidental with peak zooplankton densities." At nearshore sites in upper and middle Lake Marion, young-of-year threadfin shad (Bettinger, 2013) fed extensively on algae and unidentifiable benthic material (the source inferred by presence of sand), as well as rotifers and microcrustaceans. We speculated that pelagic threadfin shad would feed more heavily on planktonic resources, including zooplankton.

Stomachs of 67 pelagic threadfin collected from pelagic habitats in Lakes Marion and Moultrie were processed. Size of the fish ranged from 52 to 129 mm. According to preliminary summaries, diets were dominated by detritus (40-50%, depending on size class) and algae (35-50%). Zooplankton made up only 5-20% of the diets, contrary to our expectation. The rotifer *Keratella*, cyclopoid copepods, and the cladoceran *Bosmina* were the most commonly encountered taxa. We speculate that the sparsity of zooplankton in diets may reflect the generally low abundance of zooplankton in this system.

Phytoplankton dynamics model

The phytoplankton dynamics model suggests that advection is a dominant process in upper Lake Marion (Taylor, 2014). Consequently, we re-examined our parameterization of influent algal concentrations; we had initially assumed that influent algal concentrations to the upper main basin were adequately represented by samples from the Santee River. Patterson and Harvey (1992) estimated that 10% of the Santee flow was diverted from the main channel at both Rimini Trestle and Low Falls; this water enters the main basin from directly from the backwaters, rather than from the river. Based on long-term (1997-2014) records of water quality from appropriate stations, we estimate that backwater contributions could double the quantities of algae imported to the upper main basin in spring and summer. We are incorporating these new ranges of values into the simulations with the model.

Recommendations

During 2016 we will incorporate results from 2014 and 2015 fish studies into the synthesis, and we will finalize reports on all components of the project.

Literature Cited

Bettinger, J. 2013. Assessment of condition, growth, contribution to fish community, and diet of striped bass, white perch, and American shad young-of-the-year in the Santee-Cooper lakes, South Carolina. Statewide Research—Freshwater Fisheries, Annual Progress Report, South Carolina Department of Natural Resources, Columbia, South Carolina.

Bulak, J. S., J. S. Crane, D. H. Secor, & J. M. Dean. 1997. Recruitment dynamics of striped bass in the Santee-Cooper system, South Carolina. Transactions of the American Fisheries Society 126: 133-143.

Hendricks, M. K., and R. L. Noble. 1997. Feeding interactions of three planktivorous fishes in Trinidad Lake, Texas. **Proceedings of the Annual Conference, Southeastern Association of Fish and Wildlife Agencies** 51: 324-330.

Jackson, J. R., J. M. Phillips, R. L. Noble, and J. A. Rice. 1990. Relationship of planktivory by shad and diet shifts by young-of-year largemouth bass in a southern reservoir. **Proceedings of the Annual Conference, Southeastern Association of Fish and Wildlife Agencies** 44: 114-125.

Patterson, G. G., and R. M. Harvey. 1995. Retention time and flow patterns in Lake Marion, South Carolina, 1984. Water-Resources Investigations Report 95-4145. U. S. Geological Survey and South Carolina Department of Health and Environmental Control, Columbia, South Carolina, 52 pp.

Taylor, B. 2013, 2014. Trophic resources for larval fish in Lake Marion. Statewide Research—Freshwater Fisheries, Annual Progress Report, South Carolina Department of Natural Resources, Columbia, South Carolina.

Taylor, B. E., J. M. Bulak, and J. Morrison. In press. Dominance of invasive mollusks in the benthos of Lake Marion, a large impoundment in South Carolina, USA. Fundamental and Applied Limnology.

Wilson, S. 2002. Nutritional value of detritus and algae in blenny territories on the Great Barrier Reef. Journal of Experimental Marine Biology and Ecology 271: 155-169.

Prepared By: Barbara Taylor Title: Fisheries Biologist